AFFTC-TIM-06-06

INITIAL CALIBRATION OF AN F-16B PACER AIRCRAFT

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SEPTEMBER 2008

TECHNICAL INFORMATION MEMORANDUM

Controlling Office: 773 TS/ENFB, Edwards AFB, California 93524.

AIR FORCE FLIGHT TEST CENTER
EDWARDS AIR FORCE BASE, CALIFORNIA
AIR FORCE MATERIEL COMMAND
UNITED STATES AIR FORCE

This technical information memorandum (AFFTC-TIM-06-06, *Initial Calibration of an F-16B Pacer Aircraft*) was submitted under job order number 998PCR00 by the Commander, 412th Test Wing, Edwards AFB, California 93524-6843.

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This report presents the calibration results for the Air Force Flight Test Center (AFFTC) pacer aircraft. The responsible test organization was the 412th Test Wing, Edwards AFB, California. The overall test objective was to calibrate the F-16B, USAF S/N 92-0457, pacer air data system. The specific test objectives were to (1) determine the static and total source error corrections for the pacer Pitot-static systems, and (2) determine the total air temperature probe recovery factor and probe bias. Testing was conducted at the AFFTC, Edwards AFB, California and consisted of 4 flights totaling 9 flight test hours. All test objectives were met.

15. SUBJECT TERMS

air data	angle of attack	C-17	calibrated airspeed	calibration
cloverleaf	compressible dynamic pressure		dynamic pressure	F-15B
F-16	F-16B	impact pressure	level acceleration	level deceleration
Noseboom	Pacer	Pitot	Pitot-static	position error
Pressure	pressure altitude	recovery factor	static	static pressure
static source error correction		T-38C	temperature	total pressure
total source error correction		total temperature	tower flyby	trailing cone
uncertainty	uncertainty analysis	upwash	wind calculation	winds aloft

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IN MEMORIAM

This test report is dedicated to the memory of

Albert DeAnda

7 August 1921 – 8 February 2005

Air Force Flight Test Center (AFFTC) Pacer Aircraft Manager

Mr. Albert DeAnda managed the AFFTC pacer aircraft throughout most of his career, which spanned between 1954 and 2001. Mr. DeAnda provided technical assistance during the planning of this calibration program.

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PREFACE

Sincere appreciation is expressed to those members of the 418th and 445th Flight Test Squadrons who participated in the planning, execution, and support of this calibration program. In particular, the author wishes to thank Frank Brown, Katherine Wood, Donna Knighton, Robert Lamb, Jesse Ashby, and John Bryant of the 412th Test Wing and Chris Haight of JT3, LLC, for their indispensable technical expertise and assistance during the planning, execution, analysis, and reporting phases of this program.

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EXECUTIVE SUMMARY

This report presents the calibration results for the Air Force Flight Test Center (AFFTC) pacer aircraft. The responsible test organization was the 412th Test Wing, Edwards AFB, California. Testing was conducted at the AFFTC, Edwards AFB, California, from 19 November 2004 to 31 March 2005 and consisted of 4 flights totaling 9 flight test hours.

The overall test objective was to calibrate the F-16B pacer, USAF serial number 92-0457, air data system. The specific test objectives were to (1) determine the static and total source error corrections for the pacer Pitot-static systems, and (2) determine the total air temperature probe recovery factor and probe bias. All test objectives were met.

The F-16B pacer air data system was successfully calibrated between 200 KCAS and 0.93 Mach number at pressure altitudes between 2,300 and 40,000 feet. The pacer was primarily calibrated using the tower flyby method, formation flight with a C-17A aircraft equipped with a trailing cone, and level accelerations and decelerations. Additional confidence in the calibration was gained by cross-pacing with a calibrated T-38C aircraft and the retired F-15B pacer and with GPS-tracked cloverleaves. The form of the static source error correction model differed from that of the previous F-16B pacer. The new model was a function of both instrument-corrected Mach number and indicated angle of attack. The model for the previous pacer was only a function of instrument-corrected Mach number.

A small error in total pressure was measured. Two sets of data based on two different truth source aircraft were inconsistent with each other, wind tunnel data, and aerodynamic theory. The magnitudes of the total pressure errors were of the same order as the uncertainties in the errors. Since no clear conclusions could be drawn, a zero error correction was assumed.

An uncertainty analysis was performed on the pacer air data system and the flight calibration methods used. The maximum uncertainties in calibrated Mach number and pressure altitude were ±0.0021 Mach number and ±30 feet and occurred at 40,000 feet pressure altitude and 0.65 Mach number. The uncertainties decreased with decreasing altitude. The maximum uncertainty in calibrated airspeed was ±0.8 knots and occurred at 2,300 feet pressure altitude at 0.30 Mach number. The uncertainties in airspeed decreased with increasing altitude. The calibrated pressure altitude had a maximum uncertainty of ±30 feet, which was suitable for routine air data calibration work, but was probably not suitable for Reduced Vertical Separation Minimum (RVSM) work, which had accuracy requirements of ±80 feet. Note that the uncertainty of the truth source must be accounted for within the 80-foot accuracy limit. The 30-foot uncertainty in the pacer data was almost 40 percent of the 80-foot limit.

The flight test total air temperature probe was calibrated using the level acceleration and deceleration method. The total temperature probe recovery factor determined from those tests was 0.92.

In summary, the F-16B pacer was calibrated using a variety of flight test techniques that gave comparable results. A static source error correction model was developed that closely matched the flight test data. The calibrated pressure altitude had a maximum uncertainty of ±30 feet, which was suitable for routine air data calibration work, but was probably not suitable for RVSM work, which had accuracy requirements of ±80 feet. In addition, the pacer was evaluated for total pressure errors, the total air temperature probe was calibrated, and the production angle of attack system was evaluated for errors.

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INTRODUCTION

BACKGROUND

This report presents the calibration results for the Air Force Flight Test Center (AFFTC) pacer aircraft. The responsible test organization was the 412th Test Wing, Edwards AFB, California. Testing was conducted at the AFFTC, Edwards AFB, California, from 19 November 2004 to 31 March 2005 and consisted of 4 flights totaling 9 flight test hours.

The calibration program determined the total and static source error corrections (SSECs) for the F-16B pacer aircraft, USAF serial number (S/N) 92-0457. These corrections will support the use of 457 as a high-speed pacer for the calibration of other aircraft air data systems and replace the retired F-16B pacer aircraft (S/N 80-0633). Historically, pacer aircraft were used in the speed range from 200 KCAS to 0.93 Mach number and from the surface to 50,000 feet pressure altitude. The 0.93 Mach number ‘limit’ was based on the shape of the SSEC curve in the transonic range. The test team conducted testing from approach speed (11 degrees angle of attack) to 0.96 Mach number.

The pacer was calibrated using tower flybys, formation flight with a C-17A aircraft equipped with a trailing cone, formation flight with a calibrated T-38C aircraft, cloverleaves, and level accelerations and decelerations. The calibration was conducted with the intent of developing the pacer for use as a Reduced Vertical Separation Minimum (RVSM) truth source. *Guidance Material on the Approval of Operators/Aircraft for RVSM Operations*, reference 1, stated that a pacer may be used as a truth source for RVSM flight calibrations if it has been calibrated against a known standard, not against another pacer aircraft. Therefore, the SSEC model for the F-16B pacer aircraft was developed using data from the tower flybys, C-17 formation flight test points, and level accelerations only. The data from the T-38C aircraft, which was considered a pacer aircraft, are provided for reference only. The test team did not consider the C-17A aircraft to be a pacer aircraft since it was equipped with a trailing cone, which was considered to be a known standard.

The USAF Test Pilot School (TPS), Edwards AFB, California, conducted a calibration flight test program for the F-16B pacer aircraft during April 2004. They flew tower flybys, formation flight with the retired F-15B pacer aircraft (USAF S/N 76-0132), GPS-tracked level accelerations and decelerations, cloverleaves, and thrust-limited turns. The results were documented in *Air Data Calibration of F-16B S/N 92-0457 (Project True Phoenix)*, reference 2. Their calibration results did not collapse onto a single calibration curve as expected. Instead, their results seemed to vary as a function of aircraft angle of attack. The TPS test team concluded their report by recommending further data analysis and flight testing to determine why the calibration results did not conform to theory; i.e., why the calibration results did not collapse onto a single curve. This technical report provides closure to that recommendation of reference 2.

PROGRAM CHRONOLOGY

The flight test missions were accomplished as presented in table 1.

Table 1 Test Mission Chronology

Date	Mission Type	Mission Duration (hours)
19-Nov-04	End-to-end and leak checks	Not applicable
23-Nov-04	Tower flybys and cross-pace with T-38C	1.8
10-Dec-04	Formation flight with C-17 trailing cone	1.8
21-Dec-04	Formation flight with C-17 trailing cone and GPS cloverleaves	3.3
31-Mar-05	Formation flight with C-17 trailing cone and level accelerations/decelerations	2.0

TEST ITEM DESCRIPTION

The AFFTC pacer aircraft was a Coral Phoenix[1] F-16B, two-seat fighter aircraft, USAF S/N 92-0457, with a Block 15 airframe, the stronger Block 30 wings, and lighter Block 25 landing gear. The fuselage was characterized by a large bubble canopy, forebody strakes, and a small engine air inlet located under the fuselage. The aircraft was powered by a single F100-PW-220 afterburning turbofan engine with a maximum thrust of approximately 25,000 pounds and a maximum airflow of approximately 224 pounds-mass per second. For a complete description of the F-16B aircraft, refer to flight manual *USAF/EPAF Series Aircraft, F-16 A/B Block 15*, Technical Order (T.O.) 1F-16A-1, Change 14 and supplemental flight manual *USAF/EPAF Series Aircraft, F-16A/B Block 15*, T.O. 1F-16A-1-1, references 3 and 4.

A schematic of the production F-16B air data system is illustrated in figure A1. This figure has been modified to depict where the pacer Dual Sonix digital pressure encoders were connected (labeled "pacer air data system [ADS] connections"). The production air data system included a Pitot-static probe mounted on the nose that provided a dual source of static and total pressures. A second, production, five-hole air data probe was mounted on the forward right side of the fuselage, and provided another source of static and total pressures for a production central air data computer (CADC). These pressures were used by the CADC to estimate aircraft angle of attack and angle of sideslip. Two additional cone-type production angle of attack transducers were located on either side of the forward fuselage. A flight test total air temperature probe was mounted on the underside of the left forebody strake and provided the pacer air data system with a total air temperature measurement. The production total air temperature probe was mounted on the right side of the fuselage.

The special instrumentation on the F-16B pacer aircraft used the production F-16B noseboom-mounted air data probe to collect data for both total and static pressure systems. The air data probe incorporated a single Pitot port and two sets of static ports comprising two semi-independent Pitot-static systems numbered 1 and 2. Each of the Pitot-static systems was connected to calibrated Dual Sonix pressure encoders. The sensitive encoders provided input signals to the Advanced Airborne Test Instrumentation System (AATIS), which outputted engineering unit data to the pacer cockpit displays, a PC-104 flashcard memory, and a Multi-Application Recorder System-II (MARS-II) digital recorder. Appendix A presents more details on the special instrumentation system.

The pacer cockpit displayed calibrated data (data corrected for both instrument and position errors) in a digital format. Both the Pitot-static system source (system 1 or 2) presented on the display screens and the pacer system data recording rate were selectable from the rear cockpit. The PC-104 was the primary pacer data recording system and recorded calibrated data from both Pitot-static systems for post-flight analysis. The MARS-II tape recorder was used to record the AATIS pulse code modulation (PCM) data,

[1] The name 'Coral Phoenix' designates a group of F-16 aircraft originally built for Pakistan, but never delivered. These aircraft were retrofitted for use at Air Force test centers in a test support role.

voice, time code, and 1553 avionics multiplexer bus data for post-flight analysis. The AATIS PCM stream included instrument-corrected static and total pressure from both Pitot-static systems as well as total air temperature. Data from the MIL-STD-1553 bus were also recorded to the MARS-II.

Major AATIS components included the following:

1. MARS II digital recorder: recorded all AATIS instrumentation parameters, to include pacer system control unit (SCU)-3 outputs and 1553 avionics multiplex bus data.

2. PS-7000 Dual Sonix digital pressure encoders: converted total and static pneumatic pressures to digital format for the AATIS.

3. PC-104 computer: configured and programmed for serial input, digital input, digital output, and personal computer (PC) flashcard recording capability. This computer was a commercial-off-the-shelf IBM computer for industrial embedded applications.

4. GPS time code generator: provided automatic synchronization with GPS satellites to generate the IRIG-B time code.

Further information on the pacer air data system was presented in modification flight manual *USAF Series F-16A/B Aircraft, USAF Serial Number 92-0457*, reference 5.

The test aircraft was flown with two 370-gallon external fuel tanks on wing stations 4 and 6 and an advanced range data system (ARDS) pod [AN/ARQ-52(V)-5] on wingtip station 1, on the left wingtip. A single ARDS pod on the wingtip was assumed to have negligible effects on the aircraft Pitot-static system.

TEST OBJECTIVES

The overall test objective was to calibrate the F-16B pacer air data system. The specific test objectives were to determine the static and total source error corrections for the pacer Pitot-static pressure systems and to determine the total air temperature probe recovery factor and probe bias. The test objectives were met.

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TEST AND EVALUATION

PRESSURE ENCODER CALIBRATIONS

The Dual Sonix digital pressure encoders were removed from the aircraft and calibrated in a laboratory at the AFFTC between 3 and 9 November 2004. A Ruska model 6610 air data test set, with a calibration traceable to the National Institute of Standards and Technology (NIST), was used as the truth source. The Ruska had an accuracy of approximately ±0.001 inches of mercury. The Ruska produced reference pressures between 5 and 75 inches of mercury in 5-inch increments for the total pressure channel and between 4 and 30 inches of mercury in 2-inch increments for the static pressure channel. The Dual Sonix encoders were placed in an environmental chamber and calibrated at -55, -25, 0, 23, and 50 degrees C. The encoders were soaked at the test temperature for at least 2 hours prior to taking the calibration readings and remained on during the temperature soaks. The encoders were not internally compensated for temperature and therefore the instrument error corrections obtained at each temperature were different. This is discussed further in the Uncertainty Analysis section.

The calibration data obtained at 23 degrees C were used to develop the instrument error correction curves used by the onboard computer and for post-flight analyses. This temperature was chosen because most of the historical calibration data were obtained at 23 degrees C and because this was assumed to be the average temperature of the climate-controlled bay in which the Dual Sonix encoders were installed. The instrument error correction curves are tabulated in tables C1 and C2 for pacer air data systems 1 and 2, respectively. The calibration data are listed in tables C3 through C6 and are plotted in figures C1 through C4. The sensitivity of the calibration curves to temperature was approximately 0.0001 inches of mercury per degree C.

LEAK CHECKS AND END-TO-END CHECKS

The Pitot-static leak checks were performed prior to the first flight to verify the integrity of the system plumbing. Testing was accomplished using a TTU-205 Pitot-static test set. No significant leaks were found. At simulated flight conditions of 20,000 feet pressure altitude and 400 KIAS, the altitude leak rate was 12 feet per minute and the airspeed leak rate was 0.1 knots per minute. These leakages were within the AFFTC pacer limits of 100 feet per minute and 1 knot per minute. An end-to-end check was also performed using the TTU-205 to verify the proper operation of the Dual Sonix pressure encoders and the data acquisition system. The systems were functioning properly. A Pitot-static lag check was not performed.

DETERMINATION OF STATIC SOURCE ERROR CORRECTIONS

The air data system was calibrated using methods outlined in *AFFTC Standard Airspeed Calibration Procedures*, reference 6, and in appendix B. The SSECs were determined using the tower flyby technique and by flying in formation with a C-17A aircraft equipped with a trailing cone. The GPS-tracked level accelerations and decelerations were flown to extend the SSEC beyond the maximum speed of the C-17A aircraft, which was 350 KCAS or 0.825 Mach number. Additional SSEC data were obtained by cross-pacing with a calibrated T-38C aircraft and from GPS cloverleaves.

The total pressure error corrections were determined using airspeed data from the T-38C cross-pace test points and the kiel probe data from the C-17 formation test points.

Form of the Static Source Error Correction Model:

The SSECs for the new pacer aircraft differed in their functional form as compared with earlier AFFTC pacer aircraft. Historically, the SSEC model was expressed as a Mach number position error correction to be added to the instrument-corrected Mach number (ΔM_{pc}) versus instrument-corrected Mach number (M_{ic}). This model consisted of a single curve and was assumed to be applicable at all altitudes. However, calibration results from *Project True Phoenix*, reference 2 and the current effort indicated that the SSEC for the new pacer aircraft could not be modeled by a single curve.

The SSEC for the new pacer was not independent of angle of attack as it was assumed to be for earlier pacer aircraft. This is illustrated in figure C5, which shows the tower flyby results obtained at approximately 2,300 feet pressure altitude along with results obtained at 10,000; 20,000; 30,000; 35,000; and 40,000 feet pressure altitude. The results did not collapse onto a single curve as a function of Mach number. Instead, the SSECs increased (became less negative) as pressure altitude increased. This was a result of the aircraft flying at higher angles of attack at higher altitudes for a given Mach number and gross weight. Furthermore, the results of the total pressure evaluation indicated that there was an error in total pressure as a function of angle of attack. Since Mach number is a function of both total and static pressures, this meant that the SSECs could not be expressed in terms of Mach number. The SSECs were determined using altitude methods and then converted to Mach number error corrections, a process that inherently assumed zero total pressure error. Therefore, the SSEC for the new pacer was expressed as a family of curves in terms of a nondimensional (n/d) SSEC coefficient, $\Delta P_{pc}/q_{cic}$, that were functions of instrument-corrected Mach number and indicated angle of attack:

$$\frac{\Delta P_{pc}\left(M_{ic}, \alpha_i\right)}{q_{cic}} = m\left(M_{ic}\right)\alpha_i + b\left(M_{ic}\right) \tag{1}$$

where:

$\Delta P_{pc}/q_{cic}$ was the SSEC coefficient to be added to instrument-corrected static pressure (n/d)

ΔP_{pc} was truth source pressure minus the measured pressure (in Hg)

q_{cic} was the instrument–corrected compressible dynamic pressure (in Hg)

M_{ic} was the instrument-corrected Mach number (n/d)

α_i indicated angle of attack from the production F-16B CADC (degrees)

$m(M_{ic})$ was the SSEC model slope as a function of instrument-corrected Mach number (1/degree)

$b(M_{ic})$ was the SSEC model intercept as a function of instrument-corrected Mach number (n/d)

The SSEC model curves and flight test results are shown in figures C6 through C16. These data were from the April 2004 (*Project True Phoenix*, reference 2) and November 2004 tower flybys, and the March 2005 formation flight with the C-17 and level accelerations. The differences between the calculated SSECs and the model are plotted in figure C17 in nondimensional static pressure error correction coefficient units and in figure C18 in units of feet. The SSEC model was within ±0.16 percent of the instrument-corrected compressible dynamic pressure, or ±10 feet of the flight test results. The slopes and intercepts of the SSEC model are tabulated in table C7 and are plotted in figures C19 and C20.

Tower Flybys:

Tower flybys were flown to determine the SSECs at low altitudes. The passes were flown with the flaps and landing gear retracted at Mach numbers between 0.27 and 0.91. The tower flybys were flown in accordance with AFFTC Instruction 11-1, *Flying Operations, Air Operations*, reference 7, with a target altitude of 100 feet above ground level (AGL) using the production radar altimeter as a reference.

Data originally documented in *Project True Phoenix*, reference 2, were reanalyzed for this effort and were used to support the development of the SSEC model. Sixty-three test points were flown on four different days during April 2004 as a part of the TPS effort. Fourteen of those test points were repeated during November 2004 as a part of the current effort. The points were repeated for two reasons: 1) to determine if the calibration had shifted since the April flight tests, and 2) if the calibrations hadn't shifted, to demonstrate the level of repeatability of the calibration. The data analysis methods used to calculate the SSEC from the flight test data gathered during April and November are presented in appendix B.

The results from the TPS tests flown in April and the repeated tests flown in November were similar; i.e., the calibration hadn't shifted between April and November and remained repeatable. Time histories of pressure altitude and ambient air temperature measured at the flyby tower for each flight are presented in tables C8 through C12 and figures C21 through C30. The tables and figures show close agreement between the pressure and temperature data measured with the instruments used in the flyby tower and the data measured by the Edwards AFB weather service. The calculated pressure altitudes at the location of the aircraft as it flew by the tower are listed in table C13. The pacer air data are listed in table C14. The SSEC results are listed in table C15 and are plotted in terms of static pressure error correction coefficient in figures C6 through C16. The tower flyby results from the April and November test missions were extremely repeatable and were scattered less than ±6 feet, as is shown in figure C31.

Formation Flight with C-17 Trailing Cone:

The F-16B pacer was flown in formation with a C-17 (USAF S/N 87-0025, T-1) equipped with a trailing cone and a kiel probe. The static and total pressures measured by the trailing cone and kiel probe were used as truth sources to calibrate the pacer air data system. The pacer flew off of the right wing of the C-17 abeam with a bullseye painted on the side of the fuselage just aft of the paratroop door (figure B1). The bullseye was used as a reference point when maintaining formation flight and marked the location of the trailing cone pressure transducer. The two aircraft were separated by one C-17 wingspan (approximately 170 feet). Typical separation distances ranged between 137 and 240 feet, with the average being 185 feet. The C-17 trailing cone was trailed from the tip of the vertical stabilizer and was extended 150 feet. The pressures measured by the kiel probe and trailing cone pressure transducers were corrected for instrument errors. The total pressures measured by the kiel probe were corrected to the location of the trailing cone pressure transducer. The SSECs of the trailing cone were evaluated using the tower flyby method prior to the formation flight test points. The SSECs of the trailing cone were scattered ±10 feet about zero, which was within the achievable accuracy of the tower flyby method (figure C32). Thus the C-17 trailing cone data were assumed to have negligible static source errors.

Two formation flights were flown in December 2004 and one formation flight was flown in March 2005. For the December 2004 flights, the formation errors between the pacer and the C-17 were corrected by comparing the differential global positioning system (DGPS) altitude from the pacer ARDS pod with the GPS altitude from the production C-17 GPS system. For the March 2005 flight, the formation errors were corrected by comparing the DGPS altitude from the pacer ARDS pod with the DGPS altitude from a G-Lite DGPS receiver/recorder installed in the C-17 aircraft. The data from the ARDS and G-Lite DGPS receivers were processed post flight. The DGPS ground reference station located at Edwards AFB was used to apply the differential correction to the data. The data analysis

methods section (appendix B) presents more information on how the formation errors were corrected. For the test points flown in March 2005, the formation corrections ranged between 0 and -10 feet, indicating that the pacer was up to 10 feet higher than the bullseye reference point.

The March 2005 formation test points were flown at 10,000; 20,000; 30,000; 35,000; and 40,000 feet pressure altitude. The Mach number range of the test points varied with altitude, but the maximum speed reached by the C-17 was 0.80 Mach number or 350 KCAS. The air data recorded by the F-16B pacer are listed for systems 1 and 2 in tables C16 and C17. The air data recorded by the C-17 trailing cone and kiel probe are listed in table C18. The SSECs for pacer systems 1 and 2 are listed in tables C19 and C20 and are plotted in figures C6 through C16. The altitude SSECs are plotted in figure C33. The differences between the SSECs calculated from the flight test data and the SSEC model are plotted in figure C17 in nondimensional SSEC coefficient units and in figure C18 in units of feet. The SSEC model was within +0.25 and -0.16 percent of compressible dynamic pressure of the flight test results (figure C17), or +16 and -11 feet of the flight test results (figure C18).

Only the SSEC results from the March 2005 flight were used to generate the SSEC model. The data gathered during the December 2004 flights were not considered accurate enough to use to generate the SSEC model. The accuracy of the production GPS used to correct the formation errors for the December flights was unknown but was considered to be far less accurate than the G-Lite DGPS system that was used during the March flight. The data from the December flights are presented in tables C23 through C25 and are compared with the SSEC models in figures C37 through C39.

Level Accelerations and Decelerations:

The GPS-tracked level accelerations and decelerations were flown at 10,000; 20,000; 30,000; 35,000; and 40,000 feet pressure altitude on the same flight as the C-17 formation test points during March 2005. The maximum Mach number reached during the accelerations was approximately 0.96. The level accelerations and decelerations were flown in order to estimate the SSECs at Mach numbers greater than those reached during the C-17 formation test points. The relationship between geometric altitude (determined by the C-17 G-Lite DGPS data) and pressure altitude (determined by the C-17 trailing cone data) was determined and used to bias the DGPS altitude measured by the F-16B ARDS pod. The biased DGPS altitude was then used as a reference "calibrated pressure altitude" during the acceleration and deceleration. Appendix B presents the data analysis methods.

The SSEC results from the accelerations and decelerations were expected to be similar but were not (figure C34). A similar conclusion was reached by the TPS team in *Project True Phoenix*, reference 2. The SSECs determined from the level decelerations were, on average, 0.26 percent of compressible dynamic pressure more negative (or about 29 feet at 0.8 Mach number and 35,000 feet) than the SSECs determined from the level accelerations, as is shown in figures C48 through C52. The differences in the results may be attributed to the different engine power settings, and therefore, different engine airflows, used during the accelerations and decelerations. The accelerations were flown at relatively high power settings approaching military power. The decelerations were flown at idle power. The test team suspected that, at idle power, a bow wave propagated forward from the air spilling around the engine inlet. This resulted in a static pressure sensed by the noseboom that was too high relative to the pressure sensed during the accelerations. Thus the static pressure corrections determined from the decelerations were more negative than those determined from the accelerations. This is consistent with the trends shown in figures C48 through C52.

The typical pacer mission is flown with the engine at relatively high power settings, well above flight idle. Therefore, only the SSECs determined from the level accelerations were used to develop the SSEC model. The SSECs from the accelerations are plotted along with the tower flyby and C-17 formation

flight results in figures C6 through C16. The deceleration results are compared with SSEC model in figures C35 through C47 and with the acceleration results in figures C48 through C52.

Cross-Pace with the T-38C:

The new F-16B pacer was flown in formation with a T-38C aircraft, USAF S/N 64-13302 at 30,000 feet pressure altitude and at Mach numbers between 0.60 and 0.95. The SSECs for the T-38C were originally determined using tower flybys and by pacing with the retired pacers F-16B USAF S/N 80-0633 and F-15B USAF S/N 76-0132. The results of those calibrations were documented in AFFTC-TR-03-18, *T-38C Aircraft Performance Evaluation*, reference 8; AFFTC-TR-03-19, *Evaluation of an Alternate Manufacturing Source Pitot-static Tube Installed on a T-38C Aircraft*, reference 9; and AFFTC-TR-05-27, *T-38C Follow-on Aircraft Performance Evaluation*, reference 10. The T-38C SSEC was checked during this calibration test program by flying thrust-limited turns, documented in reference 10. The results of the turns indicated that the SSEC documented in references 8 and 9 was valid.

The results of the formation flight with the T-38C are presented in tables C26 through C29. The air data from the F-16B are listed in table C26. The air data from the T-38C are listed in table C27. The SSECs are listed in table C28 and are plotted in figures C36 through C44. The SSEC results generally agreed with those obtained using other methods. These results were not used to develop the SSEC model for the F-16B pacer. However, they were used to provide confidence in the SSEC model that was developed using other flight test techniques.

Cross-Pace with the F-15B Pacer:

The F-15B cross-pace test points originally documented in *Project True Phoenix*, reference 2, were reanalyzed and are plotted in figures C35 through C44. The F-15B pacer USAF S/N 76-0132 was used for this test before it was decommissioned in the summer of 2004. Formation test points were flown at 10,000; 20,000; 30,000; 35,000; and 40,000 feet pressure altitude and at Mach numbers between 0.50 and 0.95. The SSECs generally agreed with the results obtained from the C-17 formation test points and the T-38C cross-pace test points. These results were not used to develop the SSEC model for the F-16B pacer. However, they were used to provide confidence in the SSEC model that was developed using other flight test techniques.

Cloverleaves:

Cloverleaf test points were flown at 35,000 and 40,000 feet pressure altitude at 0.70, 0.80, 0.85, and 0.90 Mach number. Inertial velocities from the ARDS pod were used in the data analysis, which is outlined in AFFTC-TIH-99-01, *Aircraft Performance Flight Testing*, reference 11. The inertial data, air data, and SSECs are listed in table C30. The SSECs are plotted in figures C38 through C40. The cloverleaf flight test technique, an airspeed method, was extremely sensitive to small errors in the assumed test day ambient air temperatures and to minor variations in wind speed or direction. The SSECs were typically 0.3 percent of compressible dynamic pressure more negative than the results obtained using other methods. However, a total temperature probe recovery factor of 1.00 was used in the data analysis. Test results from the level accelerations and decelerations suggested that a recovery factor of 0.92 might have been more appropriate. Using a lower recovery factor in the data analysis would have had the effect of increasing, or making less negative, the SSECs. A recovery factor of 0.92 was too low because it would have increased the SSECs too much and resulted in positive SSECs. A recovery factor of 0.98 would have aligned the cloverleaf results with the rest of the flight test data. A discussion of using the cloverleaf data to calculate the total temperature probe recovery factor appears later in the Calibration of Total Air Temperature Probes section.

Comparisons Between F-16B Pacer Air Data Systems 1 and 2:

The SSECs for the pacer air data systems 1 and 2 were similar. Figures C53 and C54 show the differences between the SSECs for systems 1 and 2. In terms of pressure altitude, system 2 indicated a higher altitude than system 1. At 10,000 feet pressure altitude, it was necessary to add a correction of -1.5 feet to the system 2 altitudes to make them equal the system 1 altitudes. At 40,000 feet pressure altitude, it was necessary to add a correction of -10 feet to the system 2 altitudes to make them equal the system 1 altitudes.

Summary:

Data from the tower flybys, formation flight with the C-17A aircraft, and level accelerations were used to develop an SSEC model that was a function of both Mach number and angle of attack. The model was further supported with data from cross-pacing with the F-15B pacer and a calibrated T-38C aircraft, level decelerations, and GPS-tracked cloverleaves. The SSEC model matched the flight test data to within ±20 feet. **The SSEC model for system 1 should be used for in-flight and post-flight data processing (R1).**[2]

DETERMINATION OF TOTAL PRESSURE ERROR CORRECTIONS

The C-17 kiel probe and the T-38C noseboom total pressures were used as truth sources for determining the total pressure error corrections for the F-16B pacer. The kiel probe on the C-17 measured total pressure directly. On the T-38C, the total pressure was backed out from the calibrated airspeed and pressure altitude. The total pressure error correction to be added to the pacer instrument-corrected total pressure was equal to the truth source total pressure from the C-17 or T-38C minus the instrument-corrected total pressure from the F-16B pacer (tables C21, C22, and C29).

The total pressure error corrections, in the form of the non-dimensional coefficient $\Delta P_t/q_{cic}$, are plotted versus indicated angle of attack in figure C55. These results indicated that there was an error in total pressure that varied as a function of angle of attack. The C-17 data indicated a strong linear trend in the error correction that ranged between +0.002 times the instrument-corrected compressible dynamic pressure, q_{cic}, at 2 degrees angle of attack (or about 0.4 knots at 400 KCAS) and $-0.007q_{cic}$ at 9 degrees angle of attack (or about -1 knot at 200 KCAS). The data based on the T-38C noseboom supported this conclusion, although not as strongly. The T-38C data were more widely scattered and did not have the same slope as the C-17 data, but the sign of the slope was the same and the magnitudes of the corrections were similar. The results from the C-17 kiel probe were corrected for variations in formation between the pacer and the C-17 using the method outlined in appendix B. The results from the T-38C noseboom were not corrected for variations in formation, which could explain the different trend.

A small error in total pressure was identified in the Rosemount contractor report *Aerodynamic Performance of Rosemount Model 855EG Pitot-Static Tube for F-16 Aircraft*, reference 12. The total pressure errors for the tube were determined in a wind tunnel at Mach numbers between 0.2 and 2.0 and tube angles of attack between -5 and 39 degrees. The report attributed the minute total pressure errors to the "small amount of airflow from the Pitot opening through the forward portion of the 855EG, and out through the drain holes" and concluded that the errors were insignificant out to tube angles of attack of 25 degrees. The report showed small total pressure errors of approximately -0.002 times compressible dynamic pressure, q_c, at Mach numbers of 0.2 and 0.3 and below tube angles of attack of 25 degrees. However, these errors showed only a slight variation with angle of attack, on the order of $0.001q_c$. At higher subsonic Mach numbers, the errors were approximately zero and independent of tube angles of

[2] Numerals following an R represent recommendation numbers tabulated in the Conclusions and Recommendations section.

attack out to 25 degrees. Figure C56 shows the total pressure error coefficients for the F-16B pacer with the results from reference 12 superimposed. The wind tunnel results from reference 12 did not correlate with the C-17 results determined from flight test. The results from the T-38C were closer to the wind tunnel results.

The total pressure errors found in the F-16B pacer were further corroborated by data in AFFTC-TR-03-19, reference 9. In addition, that report identified two other flight test programs whose results suggested a small error in the F-16B total pressure system. The pacer aircraft referred to in those reports was the retired F-16B pacer USAF S/N 80-0633. The Pitot-static noseboom used on that aircraft was the same model as the one used on the F-16B pacer USAF S/N 92-0457. The results documented in reference 9 were of the same slope and sign, but not the same magnitude, as the results presented in this report in figure C55.

However, the total pressure error corrections did not appear to be due to source, or position, errors. A total pressure port on a noseboom at zero angle of attack was expected to have zero error, even if a static port located near the total port had a nonzero position error. This is a result of the aerodynamic premise that total pressure is constant along a streamline, whereas static pressure varies along a streamline as a function of flow velocity. As the angle of attack increases, the error in total pressure should become negative and should increase in magnitude (i.e., become more negative) with increasing angle of attack because there are both normal and tangential components of flow at the total port. The pacer data had the opposite trend: the errors were positive and became more positive as angle of attack increased. Or, in terms of error corrections to be added, the indicated total pressure was too high, and thus the error corrections were negative and became more negative as angle of attack increased. This evidence indicated that the total pressure errors were not due to position errors, or if they were, then they were masked by bias errors in both total pressure transducers that translated the errors from negative to positive. This discrepancy could have been attributed to bias errors in the Dual Sonix total pressure transducers or to problems in the C-17 kiel probe system.

The magnitudes of the total pressure error corrections were smaller than the uncertainties in those corrections, as is indicated by the error bars in figure C55. This suggested that the trend in the total pressure error corrections may have been a coincidence.

The total pressure error correction data were conflicting:

1. The C-17 and T-38C results are not strongly correlated with each other.

2. The wind tunnel results and the C-17 results were not correlated. However, the T-38C results matched the wind tunnel results.

3. The C-17 results were contrary to the expected results based on aerodynamic theory; i.e., the signs of the errors were positive when they should have been negative.

4. The magnitudes of the total pressure errors were of the same order as the uncertainties in the errors.

The evidence was inconsistent and the measured total pressure error corrections were very small. **A zero total pressure error correction should be used for in-flight and post-flight data processing (R2).**

UNCERTAINTY ANALYSIS

An uncertainty analysis was performed on the tower flyby and C-17 formation flight data. The details of the analyses are presented in appendix D. The maximum uncertainties in calibrated Mach number and pressure altitude in the flight envelope from 2,300 to 40,000 feet pressure altitude, and 200 KCAS to approximately 0.96 Mach number, were ±0.0021 Mach number and ±30 feet and occurred at 40,000 feet pressure altitude and 0.65 Mach number. The uncertainties decreased with decreasing altitude. Table 2 summarizes the uncertainties in calibrated pressure altitude. The maximum uncertainty in calibrated airspeed was ±0.8 knots and occurred at 2,300 feet pressure altitude at 0.30 Mach number. The uncertainties in airspeed decreased with increasing altitude. Table D7 and figures 1 and D10 through D12 summarize the uncertainties in calibrated Mach number, airspeed, and pressure altitude.

Table 2 Total Uncertainty in Pressure Altitude

Pressure Altitude (ft)	Total Uncertainty in Pressure Altitude for all Mach Numbers (±) (ft)
2,300	13
10,000	14
20,000	17
30,000	21
35,000	25
40,000	30

The calibrated pressure altitude had a maximum uncertainty of ±30 feet, which was suitable for routine air data calibration work, but was probably not suitable for RVSM work, which had accuracy requirements of ±80 feet. The uncertainty of the truth source must be accounted for within the 80-foot accuracy limit. The 30-foot uncertainty in the pacer data was almost 40 percent of the 80-foot limit. **The F-16B pacer aircraft, USAF S/N 92-0457, is suitable for service as the Air Force Flight Test Center-designated pacer aircraft, and should be used to support routine air data calibration missions (R3). The pacer should not be used as an RVSM truth source due to an uncertainty in calibrated pressure altitude of ±30 feet (R4).**

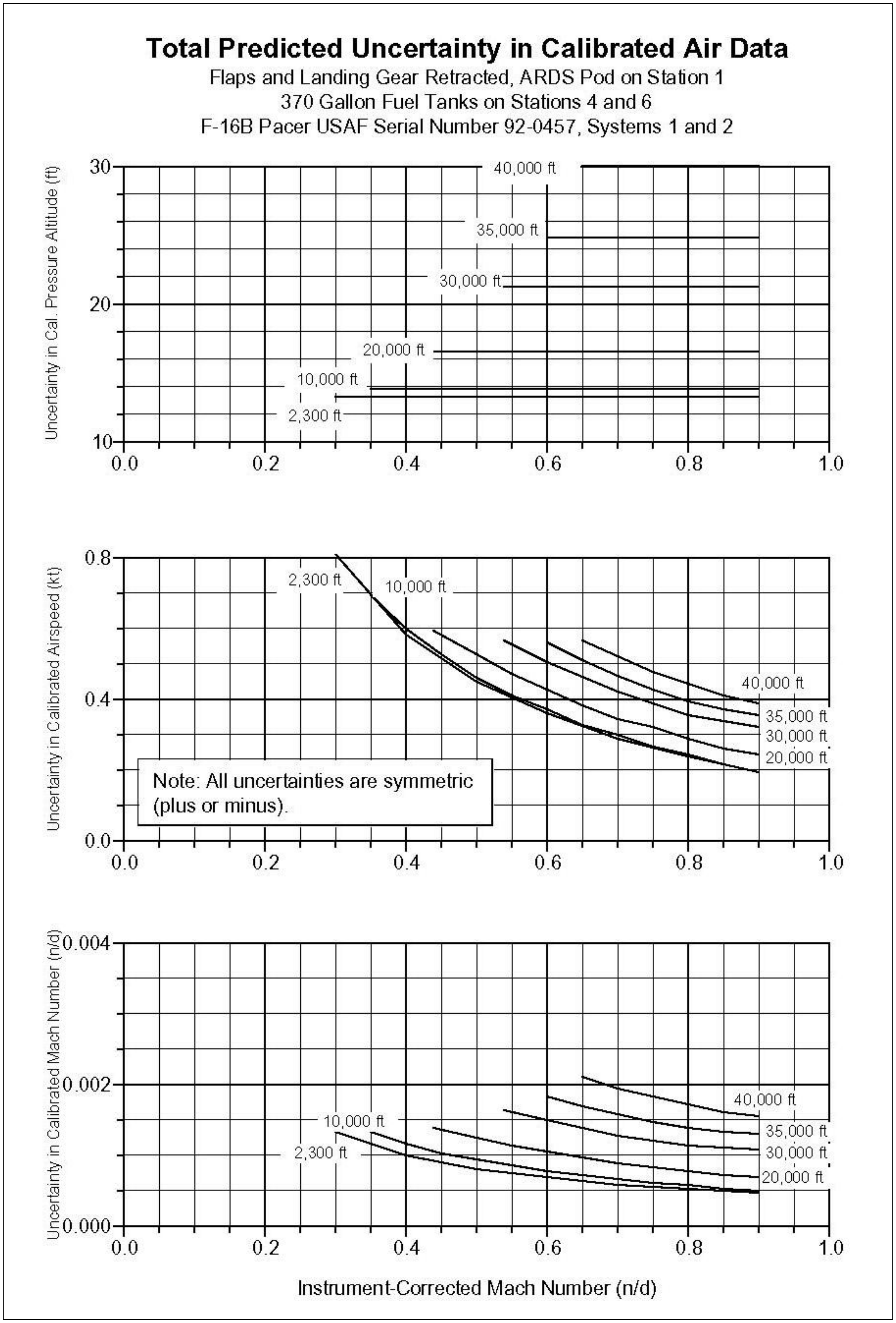

Figure 1 Total Predicted Uncertainties in Calibrated Air Data

CALIBRATION OF TOTAL AIR TEMPERATURE PROBES

The total temperature probe recovery factors were determined for the production and flight test total temperature probes. The flight test probe was inoperative during the tower flyby mission, so only the production probe was evaluated. The flight test probe was evaluated during the level accelerations and decelerations.

The recovery factor was determined by plotting $5(T_{tic}/T_a\text{-}1)$ versus the square of the calibrated Mach number, where T_{tic} was the indicated total air temperature measured by the probe, which had been corrected for instrument errors, and T_a was the assumed test-day ambient air temperature. Plotting the data in this manner resulted in a linear relationship between the ordinate and the abscissa. A linear regression analysis was performed to determine the equation of the line that best fit the data. The slope of the line was equal to the total temperature probe recovery factor.

Calibration of Production Total Temperature Probe from the Tower Flybys:

The tower flybys provided an opportunity to determine the production total temperature probe recovery factor as well as an opportunity to determine the corrections to be added to the output of the temperature probe. The temperature data measured at the flyby tower zero grid line were extrapolated up to the altitude of the aircraft and were used as the truth source in this analysis. The flight test and truth source data are listed in table C32. The results are plotted in figure C57. The recovery factor was determined by fitting a least-squares line to the data. The slope of the line was the recovery factor and the y-intercept was a bias term. The recovery factor was 0.95 and the bias term was 0.0026. Table C32 also lists the corrections to be added to the production ambient air temperature. The average value of the corrections was 0.6 degrees C.

Calibration of Flight Test Total Temperature Probe from the Level Accelerations and Decelerations:

The flight test total temperature probe recovery factor was determined from level accelerations and decelerations. The ambient air temperature was assumed to be equal to the air temperature calculated during the beginning of the acceleration when Mach number was low, assuming a recovery factor of 1.00. This temperature was assumed to remain constant throughout the level accelerations and decelerations. This was a good assumption during the accelerations when the aircraft was still relatively close to the starting point. During the decelerations, the aircraft was far away from the starting point and the assumption was more questionable. However, the ambient air temperatures calculated at the beginning of the accelerations and at the end of the decelerations remained fairly constant, as shown in table C33. With the exception of the 35,000-foot level acceleration and deceleration, the calculated temperatures changed less than 0.8 degrees C. At 35,000 feet, the calculated temperatures changed by 2.2 degrees C. Temperature data from a rawinsonde launched 10 hours prior to flying the level accelerations are also listed in the table. The calculated temperatures were within 2 degrees C of the measured temperatures, which indicated that the calculated temperatures were reasonable.

The results of the level accelerations and decelerations are plotted in figures C58 through C63 and the results are summarized in table C34. The calculated recovery factors based on the level accelerations ranged between 0.83 and 1.03. Tthe theoretical maximum is 1.00. The average of all of the results was 0.92 and the median value was 0.91. These values were unexpectedly low; the recovery factors historically used on previous pacer aircraft were on the order of 0.98 or 0.99. One possible explanation for the low values was that only subsonic data were used in the data analysis. The next two paragraphs discusses using supersonic level accelerations to more accurately determine the recovery factor. **Until**

supersonic data are obtained, a total temperature probe recovery factor of 0.92 should be used in future pacer data analysis methods (R5).

The level decelerations were not used to calculate the recovery factors because the results did not fall on top of the level acceleration results; i.e., there was an apparent 'hysteresis' in the results (figures C58 through C63). This was probably due to the wrong calibrated Mach numbers being used in the analyses. Recall that the SSECs for the level decelerations were more negative than those for the level accelerations because the power settings, and therefore the engine airflows, were different between the decelerations and accelerations. Since the SSECs were developed using the level acceleration data, the SSECs applied to the deceleration data were too small and resulted in calibrated Mach numbers that were too low. No attempt was made to develop an SSEC model using the level decelerations for the purposes of calculating the total air temperature probe recovery factors from the deceleration data.

The maximum Mach number reached during the level accelerations was approximately 0.96. It is difficult to accurately determine the total temperature probe recovery factor using only subsonic data. Typically, the recovery factor could be determined with greater accuracy if supersonic Mach numbers were reached during the level acceleration. This is a result of using the square of calibrated Mach number as the abscissa in the data analysis. For example, a level acceleration flown between 0.35 and 0.96 Mach number would result in an abscissa range between 0.12 and 0.92, over which the linear regression analysis was performed. A supersonic level acceleration flown between 0.35 and 1.60[3] would result in an abscissa range between 0.12 and 2.56. The abscissa range of the supersonic acceleration is three times larger than the range of the subsonic acceleration. A regression analysis of the supersonic acceleration is expected to result in a more accurate determination of the total temperature probe recovery factor based on the merit of the larger abscissa range. **Supersonic level accelerations and decelerations should be flown to 600 KCAS or 1.6 Mach number to determine the total temperature probe recovery factor (R6).**

Calibration of Flight Test Total Temperature Probe from the Cloverleaves:

The flight test total air temperature probe recovery factor was determined from the cloverleaf data and rawinsonde temperature data. Two rawinsondes were launched on 21 December 2004, one at 1522 GMT and a second at 1700 GMT. The 1522 balloon reached the test altitudes at approximately 1600 GMT. The 1700 balloon reached the test altitudes at approximately 1740 GMT. The cloverleaf test points were flown at 35,000 feet between 2145 and 2220 GMT and at 40,000 feet between 2038 and 2140 GMT. Thus the temperature data from the rawinsondes was almost three hours old by the time the test points were executed. Normally, the ambient air temperatures at high altitudes would be relatively constant over time, but on the day these test points were flown, the temperatures were changing rapidly. Table C35 shows the rawinsonde temperatures for the 1522 and 1700 launch times. There was a 2- to 3-degree decrease in temperature between the two balloons. Table C35 also shows the estimated temperatures at 2100 and 2200 GMT. These temperatures were calculated by extrapolating from the 1522 and 1700 GMT data using a rate of -0.022 kelvin per minute.

Table C36 shows the flight test data from each cloverleaf pass along with the rawinsonde ambient air temperatures from table C35. Figure C64 shows the total temperature probe recovery factor results calculated using the ambient air temperature data for the 1700 GMT balloon. Figure C65 shows the total temperature probe recovery factor results calculated using the extrapolated ambient air temperature data. The recovery factors, summarized in table C37, were between 0.86 and 0.91. These results supported the result from the level accelerations.

[3] The carriage limit of the external fuel tanks above 35,000 feet was 1.60 Mach number; below 35,000 feet, it was 600 KCAS.

EVALUATION OF PRODUCTION ANGLE OF ATTACK INDICATION SYSTEM

The new pacer SSEC model was a function of both Mach number and indicated angle of attack. Therefore, a limited evaluation of the production angle of attack system was performed to determine the accuracy and repeatability of the angle of attack measurements. The corrections to be added to indicated angle of attack were determined from the cloverleaves, the formation test points with the C-17 aircraft, and the level accelerations and decelerations. The results are plotted in figure C66. The corrections were determined by calculating the true angle of attack using the calibrated air data and inertial data and subtracting from that the indicated angle of attack. The true angle of attack was calculated using the methods outlined in the data analysis methods section, appendix B. Table C38 lists the data from the cloverleaf test points. The corrections were between +0.20 and -0.13 degrees. Table C39 lists the data from the C-17 formation test points. The corrections were between +0.07 and -0.40 degrees. The corrections determined from the level accelerations and decelerations were slightly larger, ranging between approximately ±1 degrees. Based on these results, the corrections applied by the production central air data computer were sufficient.

EVALUATION OF PRODUCTION RADAR ALTIMETER AND ARDS POD GEOMETRIC ALTITUDE

The flyby tower test points provided an opportunity to evaluate the production radar altimeter and the ARDS pod geometric altitude. The accuracies of both sources and the repeatability of the grid readings made by the flyby tower operator were determined. Determination of the accuracy of the ARDS DGPS altitude was especially important because that altitude was used to correct formation errors in the C-17 formation flight test points. The tower flyby grid readings were used as the truth source to determine the accuracy of the radar altimeter and the DGPS data from the ARDS pod. The heights AGL were measured directly by the radar altimeter. The DGPS geometric altitude was used to calculate height AGL by subtracting the elevation of the flyby line (2,271 feet) from the DGPS altitude. The survey results of the flyby line and flyby tower were documented in *Flyby Tower Survey Final Report*, reference 13.

The accuracies of the radar altimeter and the ARDS pod were similar. The corrections to be added to both are listed in table C40 and are plotted in figure C67. The corrections for the radar altimeter were scattered between +4 and -3 feet AGL. The corrections for the DGPS altitude were scattered between +4 and -2 feet AGL and therefore the grid readings performed by the flyby tower operator were accurate to ±0.1 grid. One increment of the grid was equal to 31.48 feet of geometric altitude at the aircraft.

EVALUATION OF WIND SPEED AND DIRECTION ALGORITHM

The cloverleaf test points provided an opportunity to evaluate the ability of the pacer to determine wind speed and direction. Recent pacer customers have used the pacer as a truth source for wind speed and direction rather than a traditional Pitot-static calibration truth source. The cloverleaf data were used to determine wind speed and direction, which were compared with rawinsonde results and results calculated by AFFTC inertial data processing software, *Performance and Flying Qualities UFTAS Link 13 User's Guide*, reference 14. The wind speeds and directions at 35,000 and 40,000 feet pressure altitude determined from the cloverleaves, Uniform Flight Test Analysis System (UFTAS) Link 13, rawinsondes, and the production F-16B inertial unit are listed in table C31. The differences were typically less than ±3 knots and ±3 degrees.

SUMMARY

The F-16B pacer was calibrated using a variety of flight test techniques that gave comparable results. A SSEC model was developed that closely matched the flight test data. The calibrated pressure altitude

had a maximum uncertainty of ±30 feet, which was suitable for routine air data calibration work, but was probably not suitable for RVSM work, which had accuracy requirements of ±80 feet. In addition, the pacer was evaluated for total pressure errors, the total air temperature probe was calibrated, and the production angle of attack system was evaluated for errors.

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CONCLUSIONS AND RECOMMENDATIONS

The F-16B pacer, USAF serial number (S/N) 92-0457, was successfully calibrated between 200 KCAS and 0.93 Mach number at pressure altitudes between 2,300 and 40,000 feet. The form of the static source error correction (SSEC) model differed from that of the previous F-16B pacer. The new model was a function of both instrument-corrected Mach number and indicated angle of attack. The model for the previous F-16B pacer was only a function of instrument-corrected Mach number.

The SSEC model for system 1 should be used for in-flight and post-flight data processing (R1, page 10).

A small error in total pressure was measured. Two sets of data based on two different truth source aircraft were inconsistent with each other and were inconsistent with wind tunnel data and aerodynamic theory. The magnitudes of the total pressure errors were of the same order as the uncertainties in the errors.

A zero total pressure error correction should be used for in-flight and post-flight data processing (R2, page 11).

An uncertainty analysis was performed on the pacer air data system and the flight calibration methods used in the flight envelope between 200 KCAS and 0.96 Mach number, and 2,300 and 40,000 feet pressure altitude. The maximum uncertainties in calibrated Mach number and pressure altitude were ±0.0021 Mach number and ±30 feet. These uncertainties occurred at 40,000 feet pressure altitude and 0.65 Mach number and decreased with decreasing altitude. The maximum uncertainty in calibrated airspeed was ±0.8 knots and occurred at 2,300 feet pressure altitude at 0.30 Mach number. The uncertainties in airspeed decreased with increasing altitude. The calibrated pressure altitude had a maximum uncertainty of ±30 feet, which was suitable for routine air data calibration work, but was probably not suitable for Reduced Vertical Separation Minimum (RVSM) work, which had accuracy requirements of ±80 feet. The uncertainty of the truth source must be accounted for within the 80-foot accuracy limit. The 30-foot uncertainty in the pacer data was almost 40 percent of the 80-foot limit.

The F-16B pacer aircraft, USAF S/N 92-0457, is suitable for service as the Air Force Flight Test Center-designated pacer aircraft, and should be used to support routine air data calibration missions (R3, page 12).

The pacer should not be used as a RVSM truth source due to an uncertainty in calibrated pressure altitude of ±30 feet (R4, page 12).

The flight test total temperature probe was calibrated using the level acceleration method. The total temperature probe recovery factors determined from those tests ranged between 0.83 and 1.03. The average of all of the results was 0.92 and the median value was 0.91.

Until supersonic data are obtained, a total temperature probe recovery factor of 0.92 should be used in future pacer data analysis methods (R5, page 15).

Supersonic level accelerations and decelerations should be flown to 600 KCAS or 1.6 Mach number to determine the total temperature probe recovery factor (R6, page 15).

A limited evaluation of the production angle of attack indicating system was performed. The corrections to be added were between +0.20 and -0.40 degrees. The corrections applied by the production central air data computer were satisfactory.

Limited evaluations of the production radar altimeter and the advanced range data system (ARDS) pod were performed. Using the tower flyby grid reading as the truth source, the corrections for the radar altimeter were scattered between +4 and -3 feet AGL and the corrections for the ARDS differential global positioning system altitude were scattered between +4 and -2 feet AGL and therefore, the grid readings performed by the flyby tower operator were accurate to ±0.1 grid.

A limited evaluation of the cloverleaf method and AFFTC wind speed and direction calculation software was performed. The cloverleaf data were used to determine wind speed and direction, which were compared with Rawinsonde results and results calculated by AFFTC inertial data processing software. The differences in calculated wind speeds and directions at 35,000 and 40,000 feet pressure altitude determined from the cloverleaves, Uniform Flight Test Analysis System (UFTAS) Link 13, Rawinsondes, and the production F-16B inertial unit were typically less than ±3 knots and ±3 degrees.

In summary, the F-16B pacer was calibrated using a variety of flight test techniques that gave comparable results. A SSEC model was developed that closely matched the flight test data. The calibrated pressure altitude had a maximum uncertainty of ±30 feet, which was suitable for routine air data calibration work, but was probably not suitable for RSVM work, which had accuracy requirements of ±80 feet. In addition, the pacer was evaluated for total pressure errors, the total air temperature probe was calibrated, and the production angle of attack system was evaluated for errors.

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APPENDIX A - TEST ITEM DESCRIPTION

PACER AIR DATA EQUIPMENT

The F-16B pacer aircraft used a pair of Dual Sonix digital pressure encoders, part number PS7000, to measure total and static pressures for the two air data systems (number 1 and 2). Both air data systems used the production noseboom and the Pitot port located at the tip of the boom. Pacer air data system 1 fed the primary system in the front cockpit (FCP). Air data system 2 fed the secondary system in the rear cockpit (RCP). The static ports were located 15.25 inches forward of the nose of the aircraft. Dual Sonix serial number 8 was installed in system 1 and serial number 14 was installed in system 2. The noseboom Pitot-static lines contained drain connections for moisture and contaminate removal. The Dual Sonix transducers were located approximately 190 inches aft of the noseboom in the left side of the fuselage.

A non-deiced Rosemount total temperature probe, model number 102E, serial number 498, was installed on the left side of the fuselage on panel number 3107. A production, de-iced total temperature probe was installed on the right side of the fuselage.

A schematic of the production F-16B air data system is illustrated in figure A1. This figure has been modified to depict where the pacer Dual Sonix digital pressure encoders were connected (labeled “Pacer ADS Connections”).

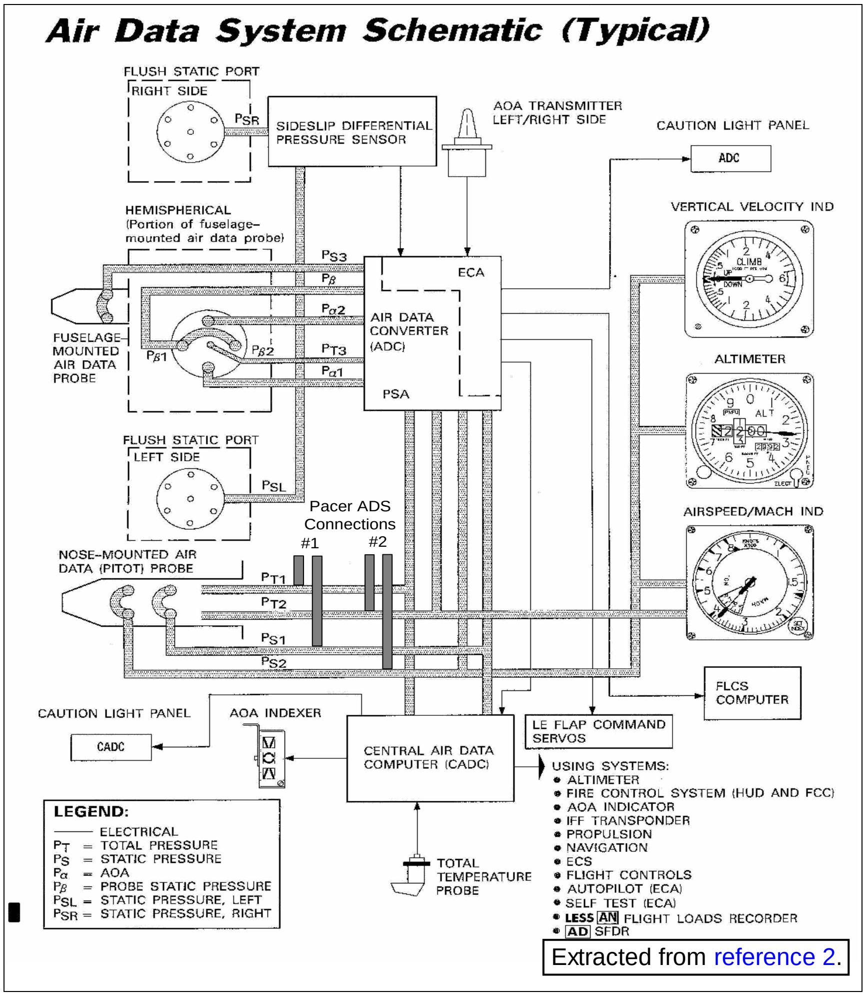

Figure A1 Schematic of Pacer Air Data System (ADS)

Pacer Parameter List:

The parameters measured by the pacer and recorded on the MARS-II recorder are listed in table A1. The processed outputs are also listed in table A1.

Table A1 Legend of Data File Parameter Names

Parameter Name	Units	Description
a	knots	Local speed of sound
alpha_a	deg	True angle of attack calculated using ARDS inertial and pacer true airspeed data
alpha_M	deg	True angle of attack calculated using ARDS pod data, calculated by MATLAB® uncertainty function
alpha_p	deg	True angle of attack calculated using F-16 inertial and pacer true airspeed data
ARDS_ALT	ft	Geometric altitude based on ARDS GPS, in units of feet mean sea level
ARDS_HGT	ft	Geometric altitude based on ARDS GPS, in units of feet above WGS84 geoid
ARDS_IPITCH	deg	ARDS pitch angle
ARDS_IROLL	deg	ARDS roll angle
ARDS_ITHD	deg	ARDS true heading angle (degrees from true north)
ARDS_LAT84	deg	ARDS latitude in the WGS84 geodetic system
ARDS_LONG84	deg	ARDS longitude in the WGS84 geodetic system
ARDS_VEO	ft/sec	ARDS inertial velocity east at the object
ARDS_VNO	ft/sec	ARDS inertial velocity north at the object
ARDS_VZO	ft/sec	ARDS inertial velocity down at the object
axb_M	g	Body axis longitudinal load factor, calculated by MATLAB uncertainty function using ARDS data
axf_a	g	Flight path axis longitudinal load factor, calculated using ARDS inertial data
axf_M	g	Flight path axis longitudinal load factor, calculated by MATLAB uncertainty function using ARDS inertial data
axf_p	g	Flight path axis longitudinal load factor, calculated using F-16 inertial data
ayb_M	g	Body axis lateral load factor, calculated by MATLAB uncertainty function using ARDS inertial data
ayf_a	g	Flight path axis lateral load factor, calculated using ARDS inertial data
ayf_M	g	Flight path axis lateral load factor, calculated by MATLAB uncertainty function using ARDS inertial data
ayf_p	g	Flight path axis lateral load factor, calculated using F-16 inertial data
azb_M	g	Body axis normal load factor, calculated by MATLAB uncertainty function using ARDS inertial data
azf_a	g	Flight path axis normal load factor, calculated using ARDS data
azf_M	g	Flight path axis normal load factor, calculated by MATLAB uncertainty function using ARDS inertial data
azf_p	g	Flight path axis normal load factor, calculated using F-16 inertial data
beta_ins_a	deg	Sideslip angle calculated using ARDS inertial and pacer true airspeed data
beta_ins_p	deg	Sideslip angle calculated using F-16 inertial and pacer true airspeed data

Table A1 Legend of Data File Parameter Names (Continued)

Parameter Name	Units	Description
beta_M	deg	Sideslip angle calculated by MATLAB uncertainty function using ARDS data
Bpsiw_M	deg	Bias uncertainty in wind direction, calculated by MATLAB uncertainty function
BVt	knots	Bias uncertainty in true airspeed, calculated by MATLAB uncertainty function
BVw_M	knots	Bias uncertainty in wind speed, calculated by MATLAB uncertainty function
Delta_Alpha_a	deg	Upwash correction to production angle of attack sensor, based on ARDS inertial data
Delta_Alpha_p	deg	Upwash correction to production angle of attack sensor, based on F-16 inertial data
Delta_M_pc1	nd	Mach number position error correction for pacer system 1
Delta_M_pc1_intercept	nd	Intercept of Mach number position error correction equation
Delta_M_pc1_slope	1/deg	Slope of Mach number position error correction equation
Delta_P_s_ic1	in_hg	Instrument error correction to Dual Sonix static pressure transducer, system 1
Delta_P_s_ic2	in_hg	Instrument error correction to Dual Sonix static pressure transducer, system 2
Delta_P_t_ic1	in_hg	Instrument error correction to Dual Sonix total pressure transducer, system 1
Delta_P_t_ic2	in_hg	Instrument error correction to Dual Sonix total pressure transducer, system 2
elx_a	ft	Longitudinal arm between aircraft center of gravity and ARDS pod
elx_p	ft	Longitudinal arm between aircraft center of gravity and F-16 inertial unit
ely_a	ft	Lateral arm between aircraft center of gravity and ARDS pod
ely_p	ft	Lateral arm between aircraft center of gravity and F-16 inertial unit
elz_a	ft	Vertical arm between aircraft center of gravity and ARDS pod
elz_p	ft	Vertical arm between aircraft center of gravity and F-16 inertial unit
FINAL_X_CG_ARDS	in	Longitudinal arm between aircraft center of gravity and ARDS pod
FINAL_X_CG_INU	in	Longitudinal arm between aircraft center of gravity and F-16 inertial unit
FINAL_Y_CG	in	Lateral arm between aircraft center of gravity and ARDS pod
FINAL_Z_CG	in	Vertical arm between aircraft center of gravity and ARDS pod
H_c	ft	Calibrated pressure altitude
H_ic1	ft	Instrument-corrected pressure altitude
M_c	nd	Calibrated Mach number
M_ic1	nd	Instrument-corrected Mach number
p	deg/sec	Time derivative of roll angle
P_s	in_hg	Static pressure
P_s_ic1	in_hg	Instrument-corrected static pressure, system 1
P_s_ic2	in_hg	Instrument-corrected static pressure, system 2

Table A1 Legend of Data File Parameter Names (Continued)

Parameter Name	Units	Description
P_t	in_hg	Total pressure
P_t_ic1	in_hg	Instrument-corrected total pressure, system 1
P_t_ic2	in_hg	Instrument-corrected total pressure, system 2
Pacer_CADC_ALPHA	deg	Indicated angle of attack from the production F-16 central air data computer
Pacer_CADC_H	ft	Production system calibrated altitude (not used in this analysis)
Pacer_CADC_VC	kt	Production system calibrated airspeed (not used in this analysis)
Pacer_CADC_VT	kt	Production system true airspeed (not used in this analysis)
Pacer_Delta_Irig	sec	Time since last data sample
Pacer_ECN	nd	Correlation number
Pacer_INU_NZ	g	F-16 inertial unit normal load factor
Pacer_INU_P	semicircles/sec	F-16 inertial unit roll rate
Pacer_INU_Pitch	deg	F-16 inertial unit pitch angle
Pacer_INU_PlatAz	deg	F-16 inertial unit platform azimuth
Pacer_INU_PSI	deg	F-16 inertial unit true heading angle
Pacer_INU_Q	semicircles/sec	F-16 inertial unit pitch rate
Pacer_INU_R	semicircles/sec	F-16 inertial unit yaw rate
Pacer_INU_Roll	deg	F-16 inertial unit roll angle
Pacer_INU_SYS_ALT	ft	F-16 inertial unit geometric altitude
Pacer_INU_VX	ft/sec	F-16 inertial unit x velocity
Pacer_INU_VY	ft/sec	F-16 inertial unit y velocity
Pacer_INU_VZ	ft/sec	F-16 inertial unit down velocity
Pacer_PSI1	in_hg	Dual Sonix indicated static pressure, system 1
Pacer_PSI2	in_hg	Dual Sonix indicated static pressure, system 2
Pacer_PTI1	in_hg	Dual Sonix indicated total pressure, system 1
Pacer_PTI2	in_hg	Dual Sonix indicated total pressure, system 2
Pacer_RALT	ft	Radar altitude
Pacer_TIC_K	degk	Total air temperature
phi_a	deg	ARDS roll angle
phi_p	deg	F-16 inertial unit roll angle
pins_a	deg/sec	ARDS roll rate
pins_p	deg/sec	F-16 inertial roll rate
Ppsiw_M	deg	Precision uncertainty in wind direction
psi_a	deg	ARDS heading angle
psi_p	deg	F-16 inertial unit heading angle
psins_a	ft/sec	Specific excess power based on ARDS data
psins_p	ft/sec	Specific excess power based on F-16 inertial data
psiw_a	deg	Wind direction calculated using ARDS data
psiw_M	deg	Wind direction calculated by the MATLAB uncertainty function using ARDS data
PVt	knots	Precision uncertainty in true airspeed

Table A1 Legend of Data File Parameter Names (Concluded)

Parameter Name	Units	Description
PVw_M	knots	Precision uncertainty in wind speed
q	deg/sec	Time derivative of pitch angle
q_c	in_hg	Compressible dynamic pressure
q_c_ic1	in_hg	Instrument-corrected compressible dynamic pressure, system 1
q_c_ic2	in_hg	Instrument-corrected compressible dynamic pressure, system 2
qins_a	deg/sec	Pitch rate using ARDS data
qins_p	deg/sec	Pitch rate using F-16 inertial data
r	deg/sec	Time derivative of heading angle
rins_a	deg/sec	Angular velocity of the airplane about the Z body axis, calculated using ARDS data
rins_p	deg/sec	Angular velocity of the airplane about the Z body axis, calculated using F-16 inertial data
T_a	degK	Ambient air temperature
theta_a	deg	ARDS pitch angle
theta_p	deg	F-16 inertial unit pitch angle
TIME	sec	Total time since January 1 2005
Upsiw_M	deg	Total uncertainty in wind direction
UVt	knots	Total uncertainty in true airspeed
Uvw_M	knots	Total uncertainty in wind speed
V_c	ft/sec	Calibrated airspeed
V_ic1	ft/sec	Instrument-corrected airspeed from system 1
V_t	knots	True airspeed
VE_Pacer	ft/sec	East inertial velocity, calculated using F-16 inertial data
VG_ARDS	ft/sec	Ground speed, calculated using the ARDS inertial data
VG_Pacer	ft/sec	Ground speed, calculated using the F-16 inertial data
VN_Pacer	ft/sec	North inertial velocity, calculated using F-16 inertial data
vw_a	knots	Wind speed, calculated using ARDS data
Vw_M	knots	Wind speed, calculated by the MATLAB uncertainty function using ARDS inertial data
vx_a	ft/sec	Rate-corrected north inertial velocity, calculated using ARDS data
vx_p	ft/sec	Rate-corrected north inertial velocity, calculated using F-16 data
vy_a	ft/sec	Rate-corrected east inertial velocity, calculated using ARDS data
vy_p	ft/sec	Rate-corrected east inertial velocity, calculated using F-16 data
vz_a	ft/sec	Rate-corrected vertical inertial velocity, calculated using ARDS data
vz_p	ft/sec	Rate-corrected vertical inertial velocity, calculated using F-16 data

Notes: 1. Parameters measured by the ARDS pod are prefixed with “ARDS”.
2. Parameters measured by the pacer data system (1553 bus, Dual Sonix pressure encoders) are prefixed with “Pacer”.
3. Calculated or derived parameters do not have a prefix. Parameters calculated using ARDS data have the suffix “_a”. Parameters calculated using production F-16 inertial reference unit data have the suffix “_p”.
4. Parameters calculated by the MATLAB uncertainty function have the suffix “_M”. All other parameters were calculated using the Air Force Flight Test Center Post Test Analysis System.

ARDS Pod Parameter List:

The parameters available from the Advanced Range Data System (ARDS) pod are listed in table A2.

Table A2 Advanced Range Data System (ARDS) Pod Parameter List

Number	Name	Units	Description
1	HMS	HMS	Time of Day (Hours, Minutes, Seconds)
2	ELAPS	Sec	Elapsed Time in Seconds from Zero Time
8	XSM	Feet	X-Smoothed (East)
9	YSM	Feet	Y-Smoothed (North)
10	ZSM	Feet	Z-Smoothed (Up)
11	LAT	Deg	Latitude (+North)
12	LONG	Deg	Longitude (+West)
13	HGT	Feet	Ellipsoid Height
110	ALT	Feet	MSL Altitude
21	VX	Ft/Sec	X-Component of Velocity
22	VY	Ft/Sec	Y-Component of Velocity
23	VZ	Ft/Sec	Z-Component of Velocity
53	HVN	Deg	Heading with Respect to North (+ Clockwise)
63	PITCH	Deg	Pitch Angle
64	YAW	Deg	Yaw Angle
71	VNO	Ft/Sec	Northward Velocity at the Object
72	VEO	Ft/Sec	Eastward Velocity at the Object
73	VZO	Ft/Sec	Upward Velocity at the Object
GEODETIC (WGS-84)			
107	LAT84	Deg	Latitude
108	LONG84	Deg	Longitude (+ West)
109	HGT84	Ft	Altitude
123	ITHD	Deg	INU True Heading in Degrees (+ Clockwise from North)
124	IPITCH	Deg	INU Pitch Angle (+ Counter Clockwise)
125	IROLL	Deg	INU Roll Angle (+ Counter Clockwise)

Special Instrumentation:

The Advanced Airborne Test Instrumentation System (AATIS) (figure A2) consisted of a system control unit (SCU-3), a virtual processor (VP), a multiple data bus monitor (MDBM) unit, and a small pulse code modulation (SPCM) unit. The SCU-3 contained a VP to convert raw pressure and temperature data into airspeed, altitude, Mach number and temperature information. These calculated engineering unit (EU) parameters were then displayed on cockpit digital display units. Raw and EU data were also recorded on a personal computer (PC)/104 flashcard and recorded on a MARS II data recorder. The aircraft was equipped with a GPS time code generator and video time inserter. The production video recorder was replaced with a Hi-8mm video deck. A general test fleet C-Band beacon was added for range support.

Control Panels and Displays.

a. Instrumentation Master Power Panel - FCP Right Console (figure A3)

b. Video Control Panel - FCP Left Console

c. 2 Digital Readouts - FCP Left Instrument Panel

d. Pacer Control Panel - RCP Left Console (figure A4)

e. Recorder Control Panel - RCP Left Console (figure A5)

f. Time Code Display (TCD) - RCP Left Console

g. 3 Digital Readouts - RCP Left Auxiliary Console (figure A6)

Switching instrumentation master power panel switch to **ON** energized relays in the power junction box (PJB) to power up the Airborne Test Instrumentation System (ATIS) power supply in the ammunition bay pallet and other pacer system components.

MARS II Tape Recorder.

The MARS-II recorder was located on ammunition pallet, accessed through the gunbay access panel. The MARS-II was a standard airborne test recorder that utilized a 20 gigabyte Digital Linear Tape (DLT®) [1] tape. The recorder had to be powered up for loading and unloading tape. The recorder was configured for avionics multiplex (AMUX) on track 7, pulse code modulation (PCM) on track 5, audio and inter-range instrumentation group B (IRIG-B) on side tracks.

AATIS.

The SPCM was located in the ammunition bay on the top shelf. It accepted analog inputs from the two Sonix PS7000 Pitot-static digital pressure encoders and one total air temperature probe. The MDBM was located on the ammunition pallet on the top shelf. The SCU-3 was located on the ammunition pallet on the bottom shelf and contained the VP. The AATIS power supply was located on the ammunition pallet on the bottom shelf.

Timing System.

A TrueTime 705-205 GPS IRIG-B receiver provided time, frequency, and position information as derived from signals transmitted by NAVSTAR global positioning satellites and was usable on a world-wide basis. If the GPS antenna had an unobstructed view to the sky, correct time would be obtained within 3 minutes. The receiver was located on the ammunition pallet on the top shelf.

PC/104.

The pacer had a PC/104 computer system to input RS-232 data from the SCU-3 VP and record those data onto a PC Type II flashcard in standard PC text file format.

The PC/104 system consisted of a small 115-volt AC to 28-volt DC power supply, a PC/104 computer, and a preflight panel. The PC/104 had one PCMCIA flash card memory slot, which accepted up to a 240-megabyte memory card. The preflight panel had an **OFF/RECORD** switch for memory removal with pacer power on. It also had a run indication to show when a print command was received by the PC/104. The print output was recorded in standard text file format on the PC flash card. Two dated

[1] Registered Trademake of Quantum Corporation, Boulder, Colorado.

files were recorded on each mission: one with a ".F16" extension that was comma and quotation delimited, and one with a ".RAW" extension. These files were able to be recognized by any PC with a PCMCIA reader and read with any text editor. The files contained one line of data per record.

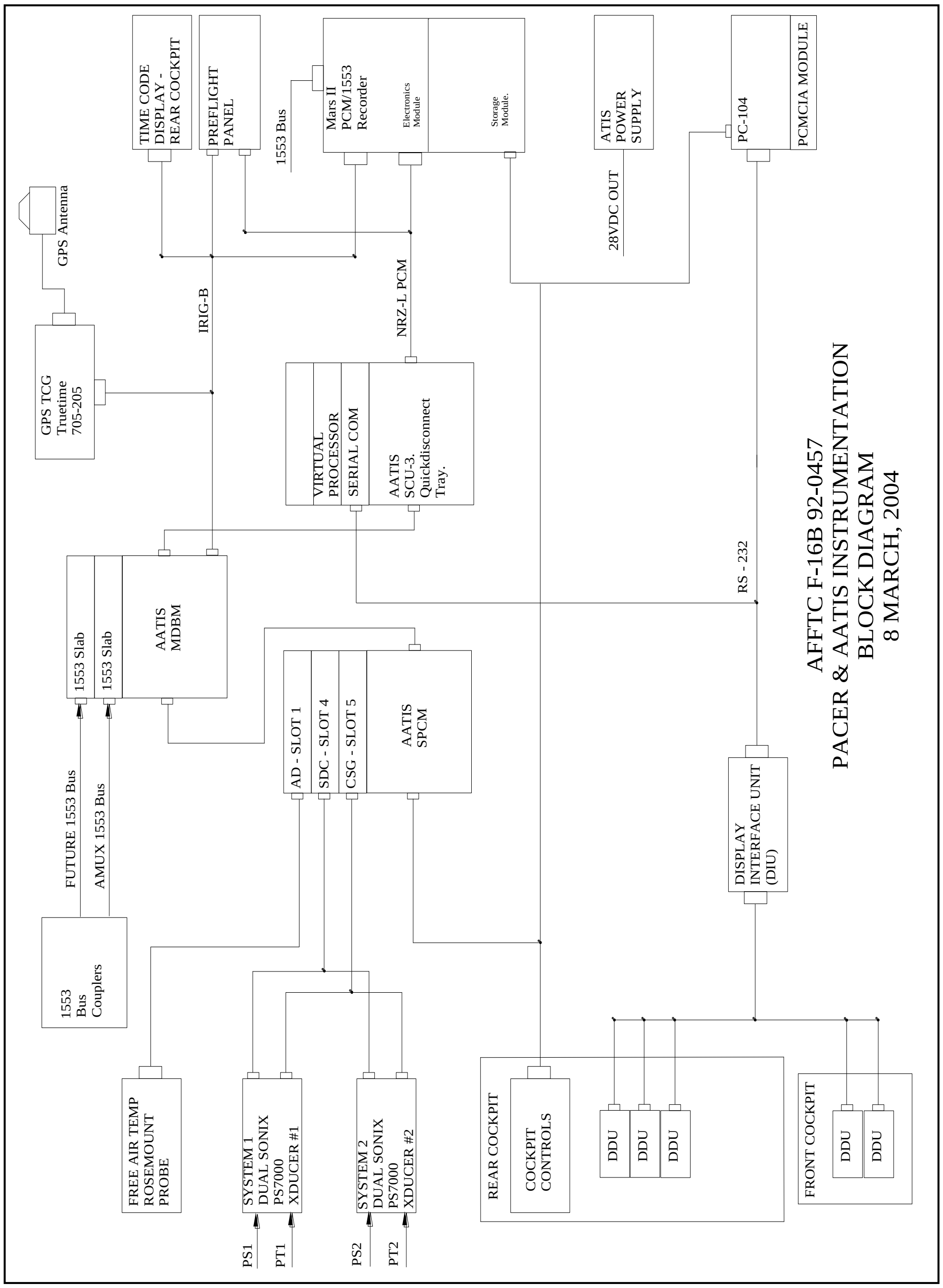

Figure A2 Pacer Special Instrumentation Schematic

Figure A3 Pacer Instrumentation Master Power Panel

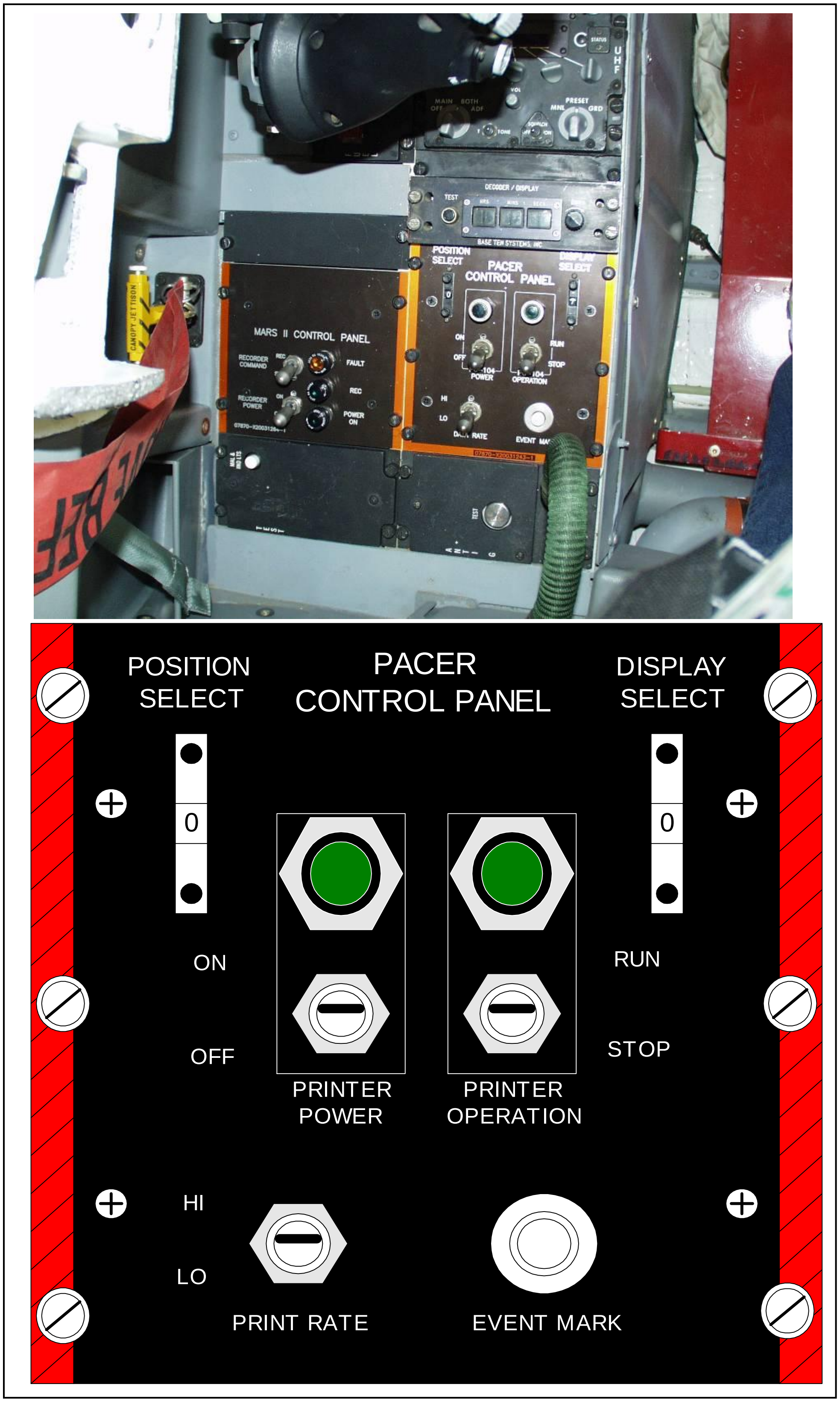

Figure A4 Pacer Control Panel

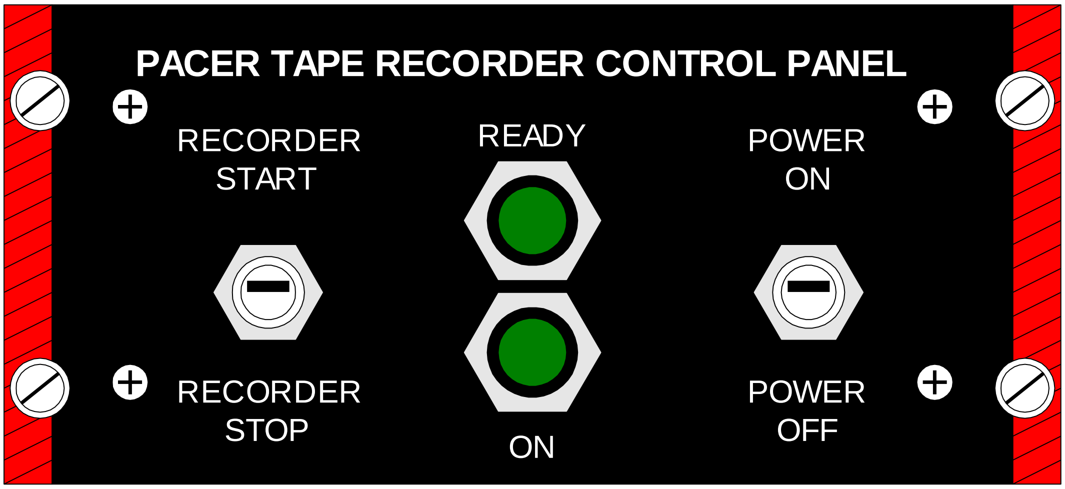

Figure A5 Pacer Tape Recorder Control Panel

Figure A6 Rear Cockpit Air Data Displays

General Dimensions.

Figure A7 shows a three-view drawing of the F-16B along with its dimensions.

Extracted from *F-16 A/B High Angle of Attack Evaluation*, reference 20

Figure A7 F-16 A/B General Arrangement

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APPENDIX B - DATA ANALYSIS METHODS

This section outlines the data analysis methods used to calibrate the Air Force Flight Test Center pacer aircraft, F-16B USAF serial number 92-0457. The Dual Sonix digital pressure encoder serial number 8 was installed in pacer Pitot-static system number 1. The Dual Sonix serial number 14 was installed in pacer Pitot-static system number 2. The two Pitot-static systems were connected to the production Pitot-static noseboom. The flight test total air temperature probe located on the left side of the fuselage was used to measure total temperature. A GPS - Advanced Range Data System (ARDS) pod was used to measure and record earth inertial reference frame velocities and Euler angles. The ARDS pod was mounted on the left wingtip (station 1).

FIRST GENERATION DATA PROCESSING

Data from the aircraft MIL-STD-1553 data bus, the Dual Sonix digital pressure encoders, and the total air temperature probe were acquired by an Advanced Airborne Test Instrumentation System (AATIS) and were recorded by a Multi-Application Recorder/Reproducer System (MARS)-II recorder. Raw test data recorded on the MARS-II tape were processed into first generation engineering units data in comma separated value format using 445th Flight Test Squadron data reduction facilities. Data from the GPS-ARDS pod, AN/ARQ-52(V)-5, were processed into engineering units. These data were corrected for aircraft angular rates from the wingtip (station 1) to the nose of the aircraft (buttock line 0, waterline 0, and fuselage station 0). The data were again corrected for angular rates from the nose to the nominal aircraft center of gravity location as outlined below.

SECOND GENERATION DATA PROCESSING

Second generation data processing was divided into two categories. The first category outlined the processes used to calculate the pacer data products. The data products available to a pacer customer were 1) calibrated values for airspeed, pressure altitude, and Mach number and 2) calculated wind speeds and directions. The second category included the data analysis methods that were used to calibrate the pacer: the tower flyby, trailing cone, level acceleration and deceleration, and cloverleaf methods.

CALCULATION OF CALIBRATED AIRSPEED, PRESSURE ALTITUDE, AND MACH NUMBER

The calibrated values for airspeed, pressure altitude, and Mach number were calculated using the following data analysis method.

The indicated static and total pressures, measured by the pacer Pitot-static systems 1 and 2 and the Dual Sonix pressure encoders, were corrected for instrument errors.

$$P_{sic} = P_{si} + \Delta P_{sic} \tag{B1}$$

$$P_{tic} = P_{ti} + \Delta P_{tic} \tag{B2}$$

where P_{sic} and P_{tic} were the instrument-corrected static and total pressures, P_{si} and P_{ti} were the indicated static and total pressures, and ΔP_{sic} and ΔP_{tic} were the static and total pressure instrument error corrections. The instrument error corrections are plotted in figures C1 through C4 and tabulated in tables C1 and C2.

The instrument-corrected compressible dynamic pressure, q_{cic}, was equal to the difference between the instrument-corrected total and static pressures.

$$q_{cic} = P_{tic} - P_{sic} \tag{B3}$$

Instrument-corrected static pressure was used to calculate instrument-corrected pressure altitude, H_{ic}. If below 36,089 feet (or ambient air pressure ratio [δ] > 0.2234), pressure altitude was:

$$H_{ic} = -145442\left[\left(\frac{P_{sic}}{P_{a_{SL}}}\right)^{0.190262} - 1\right] \tag{B4}$$

Or, if above 36,089 feet (or δ < 0.2234):

$$H_{ic} = 36089.24 - 2.08057 \times 10^{4} \ln\left(\frac{4.47708 P_{sic}}{P_{a_{SL}}}\right) \tag{B5}$$

where P_{sic} was in units of inches of mercury and P_{aSL} was equal to the ambient air pressure at sea level on a standard day (P_{aSL} = 29.92126 in Hg).

The instrument-corrected airspeed, V_{ic}, was calculated. Equation B6 was valid only for subsonic airspeeds (q_{cic}/P_a < 0.89293).

$$V_{ic} = a_{SL}\left\{5\left[\left(\frac{q_{cic}}{P_{aSL}}\right) + 1\right]^{2/7} - 1\right\}^{1/2} \tag{B6}$$

where a_{SL} was the speed of sound at sea level on a standard day (a_{SL} = 661.48 knots).

The instrument-corrected Mach number, M_{ic}, was calculated. Again, equation B7 was valid only for subsonic Mach numbers.

$$M_{ic} = \left\{5\left[\left(\frac{P_{tic}}{P_{sic}}\right)^{2/7} - 1\right]\right\}^{1/2} \tag{B7}$$

Next, the static source error correction coefficient, to be added to instrument-corrected static pressure, $\Delta P_{pc}/q_{cic}$, was calculated.

$$(\text{slope}) = f_1(M_{ic}) \tag{B8}$$

$$(\text{intercept}) = f_2(M_{ic}) \tag{B9}$$

$$\Delta P_{pc}/q_{cic} = (\text{slope})\alpha_i + (\text{intercept}) \tag{B10}$$

$$P_a = P_{sic} + \left(\frac{\Delta P_{pc}}{q_{cic}}\right) q_{cic} \tag{B11}$$

where α_i was the indicated angle of attack measured by the F-16 production angle of attack sensors and processed by the production central air data computer and P_a was the ambient air pressure. The (slope) and (intercept) functions are tabulated in table C7.

The ambient air pressure was used to calculate calibrated pressure altitude, H_c. If below 36,089 feet (or $\delta > 0.2234$), pressure altitude was:

$$H_c = -145442\left[\left(\frac{P_a}{P_{a_{SL}}}\right)^{0.190262} - 1\right] \tag{B12}$$

Or, if above 36,089 feet (or $\delta < 0.2234$):

$$H_c = 36089.24 - 2.08057 \times 10^4 \ln\left(\frac{4.47708 P_a}{P_{a_{SL}}}\right) \tag{B13}$$

The total source error correction coefficient, $\Delta P_t/q_{cic}$, was assumed to equal zero.

$$\frac{\Delta P_t}{q_{cic}} = 0 \tag{B14}$$

In subsonic flow, the total air pressure, P_t, was equal to the instrument-corrected total pressure plus the total source error correction, which was assumed to be equal to zero in equation B14.

$$P_t = P_{tic} + \left(\frac{\Delta P_t}{q_{cic}}\right) q_{cic} \tag{B15}$$

The calibrated Mach number, M_c, was a function of the total pressure and ambient air pressure. Equation B16 was valid only for subsonic speeds.

$$M_c = \left\{5\left[\left(\frac{P_t}{P_a}\right)^{2/7} - 1\right]\right\}^{1/2} \tag{B16}$$

The compressible dynamic pressure, q_c, was equal to the difference between the total and ambient air pressures.

$$q_c = P_t - P_a \tag{B17}$$

The calibrated airspeed, V_c, was calculated. Equation B17 was valid only for subsonic airspeeds (q_c/P_a < 0.89293).

$$V_c = a_{SL}\left\{5\left[\left(\frac{q_c}{P_{aSL}} + 1\right)^{2/7} - 1\right]\right\}^{1/2} \tag{B18}$$

CALCULATION OF AMBIENT AIR TEMPERATURE AND TRUE AIRSPEED

Ambient air temperature was calculated from the total air temperature measured by the flight test probe located on the left side of the fuselage.

$$T_a = T_{\mathrm{ti}}(1+0.2K_R M_{\mathrm{c}}^2)^{-1} \tag{B19}$$

where T_a was the test-day ambient air temperature, T_{ti} was the indicated total air temperature, and K_{R} was the total temperature probe recovery factor.

The local speed of sound, a, was calculated from the ambient air temperature.

$$a = a_{\mathrm{SL}}\sqrt{\frac{T_a}{T_{a\mathrm{SL}}}} \tag{B20}$$

where a_{SL} was the speed of sound at sea level on a standard day (a_{SL} = 661.48 knots) and $T_{a\mathrm{SL}}$ was the ambient air temperature at sea level on a standard day ($T_{a\mathrm{SL}}$ = 288.15 K). These values were based on the *U.S. Standard Atmosphere, 1976*, reference 15.

The true airspeed was equal to the calibrated Mach number multiplied by the local speed of sound.

$$V_{\mathrm{t}} = M_{\mathrm{c}}a \tag{B21}$$

DETERMINATION OF WIND SPEED AND DIRECTION

The local wind speed and direction were calculated by subtracting the inertial velocity vector from the flight path vector. The resultant vector was the wind vector, which was then decomposed into wind speed and direction. Note that the wind vector pointed toward the direction from which the wind was blowing. The method used was outlined in "Use of a Navigation Platform for Performance Instrumentation on the YF-16," reference 16, and "Fighter Aircraft Dynamic Performance," reference 17. The data analysis software was based on the Uniform Flight Test Analysis System Link 13 and is discussed in reference 14.

The inertial velocities in the earth inertial reference frame's north, east, and down directions were measured by an ARDS pod. The inertial velocities were corrected for aircraft angular rates because the ARDS pod was not collocated with the aircraft center of gravity. The inertial velocity data that were received by the test team had been corrected to the nose of the aircraft. The inertial velocities were then corrected from the nose to the aircraft center of gravity using the following procedure.

First, the north, east, and down inertial velocities were transformed into the aircraft body axis reference frame.

$$\begin{bmatrix} V_x \\ V_y \\ V_z \end{bmatrix}_{\mathrm{uncorrected}} = \mathbf{M}_\varphi \mathbf{M}_\theta \mathbf{M}_\psi \begin{bmatrix} V_N \\ V_E \\ V_D \end{bmatrix}_{\mathrm{uncorrected}} \tag{B22}$$

where V_x, V_y, and V_z were the body axis inertial velocities, V_N, V_E, and V_D were the north, east, and down inertial velocities, and $\mathbf{M}_\phi$, $\mathbf{M}_\theta$, and $\mathbf{M}_\psi$ were coordinate system transformation matrices given by equations B23 through B25.

$$\mathbf{M}_{\boldsymbol{\varphi}} = \begin{bmatrix} 1 & 0 & 0 \\ 0 & \cos\phi & \sin\phi \\ 0 & -\sin\phi & \cos\phi \end{bmatrix} \tag{B23}$$

$$\mathbf{M}_{\boldsymbol{\theta}} = \begin{bmatrix} \cos\theta & 0 & -\sin\theta \\ 0 & 1 & 0 \\ \sin\theta & 0 & \cos\theta \end{bmatrix} \tag{B24}$$

$$\mathbf{M}_{\boldsymbol{\psi}} = \begin{bmatrix} \cos\psi & \sin\psi & 0 \\ -\sin\psi & \cos\psi & 0 \\ 0 & 0 & 1 \end{bmatrix} \tag{B25}$$

The aircraft angular rates about the three body axes were

$$p = \dot{\phi} - \dot{\psi}\sin\theta \tag{B26}$$

$$q = \dot{\theta}\cos\phi + \dot{\psi}\cos\theta\sin\phi \tag{B27}$$

$$r = \dot{\psi}\cos\theta\cos\phi - \dot{\theta}\sin\phi \tag{B28}$$

where p, q, and r were the angular rates about the roll, pitch, and yaw axes, and ϕ, θ, and ψ were the roll, pitch, and heading Euler angles. The dot notation denotes the time derivatives of the Euler angles. The Euler angles were measured by the ARDS pod.

The body axis inertial velocities were corrected for angular rates:

$$\begin{bmatrix} V_x \\ V_y \\ V_z \end{bmatrix} = \begin{bmatrix} V_x \\ V_y \\ V_z \end{bmatrix}_{\text{uncorrected}} + \begin{bmatrix} 0 & -r & q \\ -r & 0 & -p \\ q & p & 0 \end{bmatrix} \begin{bmatrix} l_x \\ l_y \\ l_z \end{bmatrix} \tag{B29}$$

where l_x, l_y, and l_z were the distances from the aircraft center of gravity to the nose of the aircraft. The center of gravity was assumed to be located at a nominal location of buttock line 0 inches, water line 0 inches, and 35 percent of the mean aerodynamic chord (MAC). The distance from the aircraft datum (located at the nose of the aircraft) to the leading edge of the MAC was 273.11 inches and the MAC was 135.84 inches. Thus the values of l_x, l_y, and l_z were 320.65, 0, and 0 inches, respectively.

The rate-corrected body axis inertial velocities were transformed back to the earth inertial reference frame.

$$\begin{bmatrix} V_N \\ V_E \\ V_D \end{bmatrix} = \mathbf{M}_{\boldsymbol{\psi}}^{\mathbf{T}} \mathbf{M}_{\boldsymbol{\theta}}^{\mathbf{T}} \mathbf{M}_{\boldsymbol{\varphi}}^{\mathbf{T}} \begin{bmatrix} V_x \\ V_y \\ V_z \end{bmatrix} \tag{B30}$$

where the T superscript denotes a matrix transpose and V_N, V_E, V_D were the north, east, and down inertial velocities.

The wind vector was calculated by subtracting the earth inertial velocity vector (expressed as north, east, and down velocities in equation B30) from the flight path vector. First, however, the flight path vector was transformed from the flight path axis system into the earth inertial reference frame.

$$\begin{bmatrix} V_{wN} \\ V_{wE} \\ V_{wD} \end{bmatrix} = \mathbf{M}_{\boldsymbol{\psi}}^{\mathbf{T}} \mathbf{M}_{\boldsymbol{\theta}}^{\mathbf{T}} \mathbf{M}_{\boldsymbol{\varphi}}^{\mathbf{T}} \mathbf{M}_{\boldsymbol{\alpha}}^{\mathbf{T}} \mathbf{M}_{\boldsymbol{\beta}}^{\mathbf{T}} \begin{bmatrix} V_t \\ 0 \\ 0 \end{bmatrix} - \begin{bmatrix} V_N \\ V_E \\ V_D \end{bmatrix} \tag{B31}$$

where

$$\mathbf{M}_{\boldsymbol{\alpha}}^{\mathbf{T}} = \begin{bmatrix} \cos\alpha & 0 & -\sin\alpha \\ 0 & 1 & 0 \\ \sin\alpha & 0 & \cos\alpha \end{bmatrix} \tag{B32}$$

$$\mathbf{M}_{\boldsymbol{\beta}}^{\mathbf{T}} = \begin{bmatrix} \cos\beta & -\sin\beta & 0 \\ \sin\beta & \cos\beta & 0 \\ 0 & 0 & 1 \end{bmatrix} \tag{B33}$$

Equation B31 represents three equations and five unknowns: the north, east, and down components of the wind vector, V_{wN}, V_{wE}, and V_{wD}; angle of attack, α; and angle of sideslip, β. In order to solve equation B31, we assumed that the aircraft was flying with zero sideslip and that the vertical component of the wind vector was equal to zero. With these assumptions, the equation for the downward component of the wind vector may be written as:

$$V_{wD} = (-\sin\theta\cos\alpha + \cos\theta\cos\phi\sin\alpha)V_t - V_D = 0 \tag{B34}$$

A Newton-Raphson iteration was used to solve equation B34 for angle of attack:

$$\alpha = \alpha_j + \frac{f(\alpha_j)}{f'(\alpha_j)} \tag{B35}$$

where

$$f(\alpha_j) = \frac{V_D}{V_t} + \sin\theta\cos\alpha_j - \cos\theta\cos\phi\sin\alpha_j \tag{B36}$$

and

$$f'(\alpha_j) = -\sin\theta\sin\alpha_j - \cos\theta\cos\phi\cos\alpha_j \tag{B37}$$

Equation B35 was iterated until convergence within 0.00006 degrees was achieved.

Once angle of attack was estimated, equation B31 was solved for the north and east components of the wind vector. The wind vector was decomposed into wind speed (the magnitude of the vector, V_w) and the wind direction, ψ_w.

$$V_w = \sqrt{V_{wN}^2 + V_{wE}^2} \tag{B38}$$

$$V_w = \sqrt{V_{wN}^2 + V_{wE}^2} \tag{B38}$$

$$\psi_w = \arccos\left(\frac{V_{wN}}{V_w}\right) \tag{B39}$$

TOWER FLYBY DATA ANALYSIS METHOD

The tower flyby method is discussed in detail in reference 6. The flyby tower range at Edwards AFB was used to calibrate the pacer aircraft.

Readings of ambient air pressure and temperature measured at the zero grid line were recorded every 5 minutes during the tower flyby calibration mission. These data were modeled by fitting a line of least squares. The model curves for pressure altitude and ambient air temperature at the zero grid line were used to calculate the values of pressure altitude and temperature at the time the aircraft passed by the tower. The model curves were represented as functions of time:

$$H_{\mathrm{p}_{\mathrm{ZGL}}} = f(\text{time}) \tag{B40}$$

$$T_{\mathrm{a}_{\mathrm{ZGL}}} = g(\text{time}) \tag{B41}$$

where H_{pZGL} and T_{aZGL} were the pressure altitudes and temperatures at the elevation of the zero grid line.

The grid reading recorded by the observer was then converted into a tapeline altitude difference between the zero grid line and the aircraft.

$$\Delta h = 31.48 \cdot GR \tag{B42}$$

where GR was the grid reading. The resultant Δh was in units of feet of geometric, or tapeline, altitude above the zero grid line.

The standard day temperature (in kelvins), T_{aSD}, was calculated using the standard day temperature profile (reference 15) and the pressure altitude at the zero grid line.

$$T_{a_{\mathrm{SD}}} = T_{a_{\mathrm{SL}}} - 0.0019812 \cdot H_{\mathrm{p}_{\mathrm{ZGL}}} \tag{B43}$$

where $T_{a\mathrm{SL}}$ was the temperature at sea level on a standard day ($T_{a\mathrm{SL}}$ = 288.15 K).

The difference in tapeline altitude, Δh, was converted to a difference in pressure altitude by correcting for non-standard day temperature.

$$\Delta H_{\mathrm{p}} = \Delta h \cdot \frac{T_{\mathrm{a}_{\mathrm{SD}}}}{T_{\mathrm{a}_{\mathrm{ZGL}}}} \tag{B44}$$

where ΔH_{p} was the difference in pressure altitude between the zero grid line and the aircraft.

The pressure altitude at the location of the aircraft, H_{c}, was calculated by adding ΔH_{p} to the pressure altitude at the zero grid line.

$$H_{\mathrm{c}} = H_{\mathrm{p}_{\mathrm{ZGL}}} + \Delta H_{\mathrm{p}} \tag{B45}$$

The ambient air pressure corresponding to H_c was calculated using the equation from the standard atmosphere for altitudes below 36,089 feet.

$$P_a = P_{a_{\mathrm{SL}}}(1 - 6.87558 \times 10^{-6} \cdot H_{\mathrm{c}})^{5.25591} \tag{B46}$$

Next, the total and static air pressures measured by the Dual Sonix digital pressure encoders on the pacer aircraft were corrected for instrument errors. The instrument error corrections are plotted in figures C1 through C4 and tabulated in tables C1 and C2.

$$P_{\mathrm{sic}} = P_{\mathrm{si}} + \Delta P_{\mathrm{sic}} \tag{B47}$$

$$P_{\mathrm{tic}} = P_{\mathrm{ti}} + \Delta P_{\mathrm{tic}} \tag{B48}$$

The instrument-corrected compressible dynamic pressure, q_{cic}, was equal to the difference between the instrument-corrected total and static pressures.

$$q_{\mathrm{cic}} = P_{\mathrm{tic}} - P_{\mathrm{sic}} \tag{B49}$$

The static source error correction coefficient was equal to the difference between the ambient air pressure and the instrument-corrected air pressure, all divided by the compressible dynamic pressure.

$$\frac{\Delta P_{\mathrm{pc}}}{q_{\mathrm{cic}}} = \frac{P_a - P_{\mathrm{sic}}}{q_{\mathrm{cic}}} \tag{B50}$$

TRAILING CONE DATA ANALYSIS METHOD

The pacer aircraft flew in formation with a C-17 aircraft equipped with a trailing cone and kiel probe. The static pressures measured by the trailing cone and the total pressures measured by the kiel probe were used as truth sources for calibrating the pacer. The trailing cone pressure transducer was located just aft of the right hand paratroop door (figure B1). A black bull's eye was painted on either side of the fuselage marking the location of the pressure transducer. The pacer aircraft maintained formation flight with the bull's eye at a distance of 340 feet (approximately 2 C-17 wingspans) from the C-17 wingtip. This ensured that the pacer was outside of the C-17 pressure field. Each test point was between 30 seconds and one minute long. During that time, the pacer would inadvertently drift upward or downward with respect to the C-17 aircraft. These formation errors were removed by applying an altitude correction that was developed by comparing the DGPS altitudes of both aircraft. The F-16B was equipped with an ARDS pod that provided DGPS altitudes. The C-17 aircraft was equipped with a G-Lite which also provided DGPS altitudes.

The first step in the trailing cone data analysis was to calculate instrument-corrected total and static pressures from the Dual Sonix pressure encoders on the pacer. The instrument error corrections are plotted in figures C1 through C4 and tabulated in tables C1 and C2.

$$P_{\mathrm{sic}} = P_{\mathrm{si}} + \Delta P_{\mathrm{sic}} \tag{B51}$$

$$P_{\mathrm{tic}} = P_{\mathrm{ti}} + \Delta P_{\mathrm{tic}} \tag{B52}$$

$$H_{\text{ic}} = -145442\left[\left(\frac{P_{\text{sic}}}{P_{a_{\text{SL}}}}\right)^{0.190262} - 1\right] \tag{B53}$$

Or, if above 36,089 feet (or $\delta < 0.2234$):

$$H_{\text{ic}} = 36089.24 - 2.08057 \times 10^{4} \ln\left(\frac{4.47708 P_{\text{sic}}}{P_{a_{\text{SL}}}}\right) \tag{B54}$$

where P_{sic} was in units of inches of mercury and $P_{a\text{SL}}$ was equal to the ambient air pressure at sea level on a standard day ($P_{a\text{SL}}$ = 29.92126 in Hg).

The instrument-corrected Mach number, M_{ic}, was a function of the instrument-corrected total and static air pressures. Equation B55 was valid only for subsonic speeds.

$$M_{\text{ic}} = \left\{5\left[\left(\frac{P_{\text{tic}}}{P_{\text{sic}}}\right)^{2/7} - 1\right]\right\}^{1/2} \tag{B55}$$

Ambient air temperature was estimated from the instrument-corrected Mach number and the total air temperature measured by the flight test probe located on the left side of the fuselage.

$$T_a = T_{\text{ti}}(1+0.2K_R M_{\text{ic}}^{2})^{-1} \tag{B56}$$

where T_a was the ambient air temperature, T_{ti} was the indicated total air temperature, and K_{R} was the total temperature probe recovery factor.

The standard day temperature (in kelvins) was calculated using the standard day temperature profile (reference 15) and the instrument-corrected pressure altitude. If below 36,089 feet pressure altitude, the equation was:

$$T_{a_{SD}} = T_{a_{SL}} - 0.0019812 \cdot H_{ic} \tag{B57}$$

where T_{aSL} was the standard day temperature at sea level on a standard day (T_{aSL} = 288.15 K). Above 36,089 feet pressure altitude, the standard day temperature was constant.

$$T_{aSD} = 216.66 \text{ K} \tag{B58}$$

The C-17 DGPS altitude was corrected from the location of the DGPS antenna to the location of the trailing cone pressure transducer (figure B1). Variations in the C-17 pitch angle were considered.

$$\Delta h_{\theta,\text{C-17}} = (\text{-26.17 ft}) \sin \theta_{\text{C-17}} + (\text{-11.67 ft}) \cos \theta_{\text{C-17}} \tag{B59}$$

where $\theta_{\text{C-17}}$ was the pitch angle measured by the C-17 inertial reference unit and the constants represented the distances longitudinally and vertically between the DGPS antenna and the trailing cone pressure transducer.

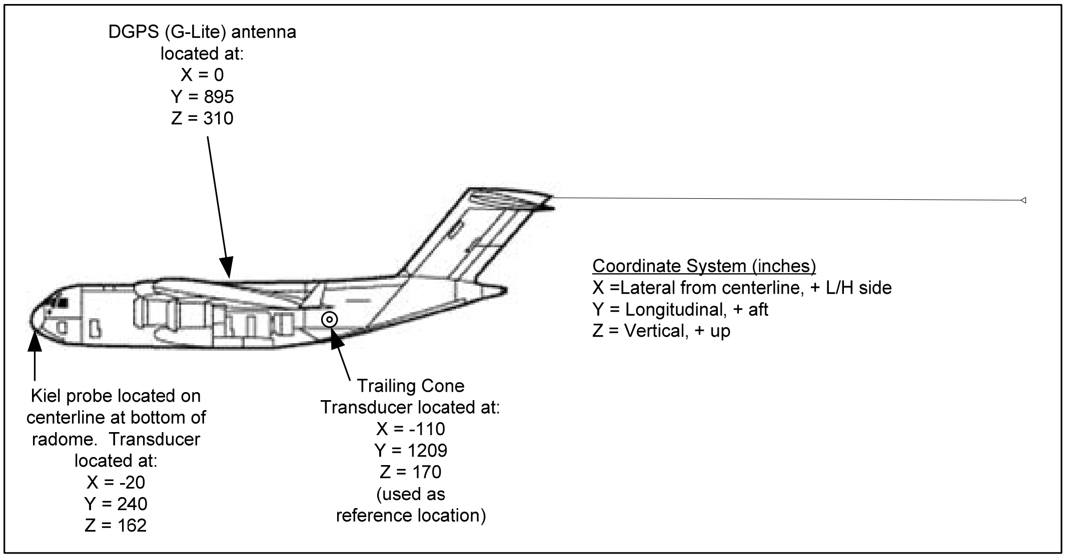

Figure B1 C-17 Special Instrumentation Layout

The formation errors between the pacer and the C-17 aircraft were corrected by comparing the DGPS altitudes between the two aircraft. The GPS correction to be added to the pacer instrument-corrected pressure altitude, corrected for non-standard day temperature, was:

$$\Delta H_{GPS} = \left(h_{\mathrm{GPS,C-17}} + \Delta h_{\theta,\mathrm{C-17}} - h_{\mathrm{GPS,ARDS}}\right)\frac{T_{aSD}}{T_a} \tag{B60}$$

The "corrected" instrument-corrected static pressure, corrected for variations in the pacer formation with respect to the C-17 aircraft, was calculated from the sum of the instrument-corrected pressure altitude and the GPS correction. If below 36,089 feet pressure altitude (or $\delta > 0.2234$), the equation was:

$$P_{\mathrm{sic,corr}} = P_{aSL}\left[1 - 6.87558\times10^{-6}\left(H_{\mathrm{ic}} + \Delta H_{\mathrm{GPS}}\right)\right]^{5.25591} \tag{B61}$$

Or, if above 36,089 feet pressure altitude (or $\delta < 0.2234$):

$$P_{\mathrm{sic,corr}} = P_{a\mathrm{SL}} \cdot 0.22336\exp\{-4.80637x10^{-5}[(H_{\mathrm{ic}} + \Delta H_{\mathrm{GPS}}) - 36089.24]\} \tag{B62}$$

The instrument-corrected total air pressure from the pacer was also corrected for variations in pacer formation with respect to the C-17 aircraft. Total pressure was equal to the sum of the static pressure and the compressible dynamic pressure:

$$P_{\mathrm{tic}} = P_{\mathrm{sic}} + q_{\mathrm{cic}} \tag{B63}$$

The compressible dynamic pressure was assumed to be independent of the variations in pacer/C-17 aircraft formation. Therefore, the total pressure was corrected by adding a correction to the static pressure component in equation B63. The static pressure component correction is developed in equations B64 through B72.

The total pressure measured by the C-17 kiel probe was corrected back to the location of the trailing cone pressure transducer. The difference in pressure altitude between the trailing cone pressure transducer and the kiel probe pressure transducer ($\Delta H_{\theta,\mathrm{kiel}}$) was a function of C-17 pitch angle.

$$\Delta H_{\theta,\mathrm{kiel}} = \left(-80.75 \sin\theta_{\mathrm{C\text{-}17}} + 0.67 \cos\theta_{\mathrm{C\text{-}17}}\right) \frac{T_{a\mathrm{SD}}}{T_a} \tag{B64}$$

The constants in equation B64 represented the distances longitudinally and vertically between the kiel probe pressure transducer and the trailing cone pressure transducer (figure B1). The pressure altitude at the location of the C-17 trailing cone pressure transducer was calculated from the trailing cone static pressure corrected for instrument errors, $P_{\mathrm{s,cone}}$. If below 36,089 feet (or δ > 0.2234), pressure altitude was:

$$H_{\mathrm{cone}} = -145442 \left[\left(\frac{P_{\mathrm{s,cone}}}{P_{a_{\mathrm{SL}}}} \right)^{0.190262} - 1 \right] \tag{B65}$$

Or, if above 36,089 feet (or δ < 0.2234):

$$H_{\mathrm{cone}} = 36089.24 - 2.08057 \times 10^4 \ln\left(\frac{4.47708 P_{\mathrm{s,cone}}}{P_{a_{\mathrm{SL}}}} \right) \tag{B66}$$

The pressure altitude at the location of the kiel probe pressure transducer was equal to the pressure altitude at the location of the trailing cone pressure transducer minus the pitch correction of equation B64.

$$H_{\mathrm{kiel}} = H_{\mathrm{cone}} - \Delta H_{\theta,\mathrm{kiel}} \tag{B67}$$

The pressure altitude at the location of the kiel probe was converted back into a static pressure. If below 36,089 feet pressure altitude (or δ > 0.2234), the equation was:

$$P_{\mathrm{s,kiel}} = P_{aSL} \left[1 - 6.87558 \times 10^{-6} \left(H_{\mathrm{kiel}} \right) \right]^{5.25591} \tag{B68}$$

Or, if above 36,089 feet pressure altitude (or δ < 0.2234):

$$P_{\mathrm{s,kiel}} = P_{a\mathrm{SL}} \cdot 0.22336 \exp\left\{ -4.80637 \times 10^{-5} \left[\left(H_{\mathrm{kiel}} \right) - 36089.24 \right] \right\} \tag{B69}$$

The correction to be added to the kiel probe total pressure, to correct it to the location of the trailing cone pressure transducer, was equal to the difference between the static pressure measured by the trailing cone pressure transducer and the static pressure at the location of the kiel probe.

$$\Delta P_{\mathrm{kiel}} = P_{\mathrm{s,cone}} - P_{\mathrm{s,kiel}} \tag{B70}$$

The kiel probe total pressure was corrected to the location of the trailing cone pressure transducer.

$$P_{\mathrm{t,kiel,corr}} = P_{\mathrm{t,kiel}} + \Delta P_{\mathrm{kiel}} \tag{B71}$$

The pressure correction to be added to the pacer total pressure was equal to the pressure increment corresponding to the pressure altitude increment from equation B60:

The pressure correction to be added to the pacer total pressure was equal to the pressure increment corresponding to the pressure altitude increment from equation B60:

$$\Delta P_{\mathrm{s}} = P_{\mathrm{sic,corr}} - P_{\mathrm{sic}} \tag{B72}$$

The pacer total pressure corrected to the same pressure altitude as the C-17 trailing cone pressure transducer was:

$$P_{\mathrm{tic,corr}} = P_{\mathrm{tic}} + \Delta P_{\mathrm{s}} \tag{B73}$$

The instrument-corrected compressible dynamic pressure was equal to the difference between the instrument-corrected total and static pressures corrected to the same pressure altitude as the C-17 trailing cone pressure transducer.

$$q_{\mathrm{cic,corr}} = P_{\mathrm{tic,corr}} - P_{\mathrm{sic,corr}} \tag{B74}$$

The static source error correction coefficient was equal to the difference between the static air pressure measured by the C-17 trailing cone and the pacer instrument-corrected static pressure corrected for formation errors, all divided by the instrument-corrected compressible dynamic pressure corrected for formation errors.

$$\frac{\Delta P_{\mathrm{pc}}}{q_{\mathrm{cic,corr}}} = \frac{P_{\mathrm{s,cone}} - P_{\mathrm{sic,corr}}}{q_{\mathrm{cic,corr}}} \tag{B75}$$

The total source error correction coefficient was equal to the difference between the corrected C-17 kiel total pressure and the pacer instrument-corrected total pressure corrected for formation errors, all divided by the instrument-corrected compressible dynamic pressure corrected for formation errors.

$$\frac{\Delta P_{t}}{q_{\mathrm{cic,corr}}} = \frac{P_{\mathrm{t,kiel,corr}} - P_{\mathrm{tic,corr}}}{q_{\mathrm{cic,corr}}} \tag{B76}$$

LEVEL ACCELERATION AND DECELERATION DATA ANALYSIS METHOD

The level accelerations and decelerations were flown in order to estimate the static source error corrections at Mach numbers greater than those reached during the C-17 aircraft formation test points. The relationship between geometric altitude (determined by the C-17 G-Lite DGPS data) and pressure altitude (determined by the C-17 trailing cone data) was determined and used to bias the DGPS altitude measured by the F-16B ARDS pod. The biased DGPS altitude was then used as a reference “calibrated pressure altitude” during the acceleration and deceleration.

The calibrated pressure altitude was calculated using the C-17 trailing cone static pressure. If below 36,089 feet (or $\delta > 0.2234$), pressure altitude was:

$$H_{\mathrm{c}} = -145442\left[\left(\frac{P_{\mathrm{s,cone}}}{P_{a_{\mathrm{SL}}}}\right)^{0.190262} - 1\right] \tag{B77}$$

Or, if above 36,089 feet (or $\delta < 0.2234$):

$$H_c = 36089.24 - 2.08057 \times 10^4 \ln\left(\frac{4.47708 P_{s,cone}}{P_{a_{SL}}}\right) \tag{B78}$$

where $P_{s,cone}$ was in units of inches of mercury and P_{aSL} was equal to the ambient air pressure at sea level on a standard day (P_{aSL} = 29.92126 in Hg).

Next, a "bias" correction was calculated and added to the F-16B ARDS pod DGPS altitude. The bias was equal to the calibrated pressure altitude from the C-17 trailing cone minus the C-17 G-Lite DGPS altitude. The bias was calculated using data from the final formation test point between the C-17 aircraft and F-16B aircraft.

$$(\text{bias}) = H_c - h_{GPS,C\text{-}17} \tag{B79}$$

A "reference pressure altitude," h_{ref}, was calculated by adding the bias to the F-16B ARDS pod DGPS altitude.

$$h_{ref} = h_{GPS,ARDS} + (\text{bias}) \tag{B80}$$

The reference pressure altitude was used to estimate the calibrated pressure altitude during the level acceleration and deceleration. In order to calculate the static source error corrections, the reference pressure altitude was converted into a pressure. If below 36,089 feet pressure altitude (or $\delta > 0.2234$), the equation was:

$$P_a = P_{aSL}\left[1 - 6.87558 \times 10^{-6}\left(h_{ref}\right)\right]^{5.25591} \tag{B81}$$

Or, if above 36,089 feet pressure altitude (or $\delta < 0.2234$):

$$P_a = P_{aSL} \cdot 0.22336 \exp\left\{-4.80637 \times 10^{-5}\left[\left(h_{ref}\right) - 36089.24\right]\right\} \tag{B82}$$

Next, the total and static air pressures measured by the Dual Sonix digital pressure encoders on the pacer aircraft were corrected for instrument error. The instrument error corrections are plotted in figures C1 through C4 and tabulated in tables C1 and C2.

$$P_{sic} = P_{si} + \Delta P_{sic} \tag{B83}$$

$$P_{tic} = P_{ti} + \Delta P_{tic} \tag{B84}$$

The instrument-corrected compressible dynamic pressure, q_{cic}, was equal to the difference between the instrument-corrected total and static pressures.

$$q_{cic} = P_{tic} - P_{sic} \tag{B85}$$

The static source error correction coefficient was equal to the difference between the ambient air pressure and the instrument-corrected air pressure, all divided by the compressible dynamic pressure.

$$\frac{\Delta P_{pc}}{q_{cic}} = \frac{P_a - P_{sic}}{q_{cic}} \tag{B86}$$

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APPENDIX C - DATA TABLES

Table C1 Instrument-Error Correction Curve for Pacer System 1

Total Pressure		Static Pressure	
Indicated Pressure (in Hg)	Correction to be Added (in Hg)	Indicated Pressure (in Hg)	Correction to be Added (in Hg)
5	0.00184	4	-0.00855
10	-0.00144	6	-0.00878
15	-0.00426	8	-0.00898
20	-0.00666	10	-0.00915
25	-0.00866	12	-0.00930
30	-0.01033	14	-0.00942
35	-0.01168	16	-0.00951
40	-0.01277	18	-0.00959
45	-0.01363	20	-0.00963
50	-0.01429	22	-0.00965
55	-0.01481	24	-0.00965
60	-0.01522	26	-0.00961
65	-0.01556	28	-0.00956
70	-0.01587	30	-0.00948
75	-0.01618	---	---

Notes: 1. Dual Sonix serial number 8 was installed in system 1.
2. The correction curve was valid at 23 degrees C.
3. 9 November 2004.

Table C2 Instrument-Error Correction Curve for Pacer System 2

Total Pressure		Static Pressure	
Indicated Pressure (in Hg)	Correction to be Added (in Hg)	Indicated Pressure (in Hg)	Correction to be Added (in Hg)
5	0.00770	4	-0.01039
10	0.00398	6	-0.01034
15	0.00105	8	-0.01016
20	-0.00120	10	-0.00987
25	-0.00287	12	-0.00949
30	-0.00404	14	-0.00905
35	-0.00482	16	-0.00857
40	-0.00529	18	-0.00807
45	-0.00556	20	-0.00757
50	-0.00573	22	-0.00710
55	-0.00587	24	-0.00668
60	-0.00610	26	-0.00633
65	-0.00651	28	-0.00607
70	-0.00719	30	-0.00593
75	-0.00824	---	---

Notes: 1. Dual Sonix serial number 14 was installed in system 2.
2. The correction curve was valid at 23 degrees C.
3. 9 November 2004.

Table C3 Instrument-Error Corrections to be Added to the Dual Sonix Indicated Static Pressure - System 1

	23 deg C 17-Sep-03		23 deg C 5-Nov-04		-55 deg C 8-Nov-04		-25 deg C 8-Nov-04		0 deg C 9-Nov-04		50 deg C 9-Nov-04		23 deg C 9-Nov-04	
Input	Output	Correction	Output	Correction	Output	Correction	Output	Correction	Output	Correction	Output	Correction	Output	Correction
4.000	4.0128	-0.013	4.0157	-0.016	4.0080	-0.008	4.0031	-0.003	4.0168	-0.017	4.0238	-0.024	4.0200	-0.020
6.000	6.0126	-0.013	6.0152	-0.015	6.0078	-0.008	6.0026	-0.003	6.0161	-0.016	6.0255	-0.026	6.0201	-0.020
8.000	8.0124	-0.012	8.0141	-0.014	8.0076	-0.008	8.0026	-0.003	8.0151	-0.015	8.0256	-0.026	8.0164	-0.016
10.000	10.0114	-0.011	10.0131	-0.013	10.0075	-0.008	10.0023	-0.002	10.0153	-0.015	10.0263	-0.026	10.0104	-0.010
12.000	12.0110	-0.011	12.0126	-0.013	12.0073	-0.007	12.0019	-0.002	12.0145	-0.015	12.0276	-0.028	12.0067	-0.007
14.000	14.0102	-0.010	14.0118	-0.012	14.0071	-0.007	14.0014	-0.001	14.0132	-0.013	14.0278	-0.028	14.0068	-0.007
16.000	16.0100	-0.010	16.0102	-0.010	16.0075	-0.008	16.0016	-0.002	16.0110	-0.011	16.0261	-0.026	16.0072	-0.007
18.000	18.0082	-0.008	18.0104	-0.010	18.0064	-0.006	18.0011	-0.001	18.0096	-0.010	18.0266	-0.027	18.0068	-0.007
20.000	20.0092	-0.009	20.0088	-0.009	20.0068	-0.007	19.9995	0.000	20.0065	-0.006	20.0260	-0.026	20.0055	-0.006
22.000	22.0074	-0.007	22.0072	-0.007	22.0052	-0.005	22.0002	0.000	22.0024	-0.002	22.0277	-0.028	22.0057	-0.006
24.000	24.0078	-0.008	24.0068	-0.007	24.0061	-0.006	23.9997	0.000	24.0014	-0.001	24.0227	-0.023	24.0055	-0.006
26.000	26.0070	-0.007	26.0074	-0.007	26.0058	-0.006	25.9992	0.001	26.0013	-0.001	26.0236	-0.024	26.0062	-0.006
28.000	28.0073	-0.007	28.0052	-0.005	28.0057	-0.006	27.9993	0.001	28.0023	-0.002	28.0233	-0.023	28.0068	-0.007
30.000	30.0077	-0.008	30.0042	-0.004	30.0060	-0.006	29.9992	0.001	30.0018	-0.002	30.0217	-0.022	30.0058	-0.006

Notes:
1. Dual Sonix digital pressure encoder serial number 8 was installed in pacer system 1.
2. Input, Output, and Correction are pressures measured in inches of Mercury.
3. The calibration tests were performed on the specified dates.
4. The Dual Sonix was soaked at the specified temperature in the environmental chamber for at least 2 hours prior to taking readings.
5. Power was on Dual Sonix unit throughout the testing.
6. A Ruska 6610 with an accuracy of approximately ±0.001 inches of mercury was used to provide the reference pressures.

Table C4 Instrument-Error Corrections to be Added to the Dual Sonix Indicated Static Pressure - System 2

	23 deg C 17-Sep-03		23 deg C 5-Nov-04		-55 deg C 8-Nov-04		-25 deg C 8-Nov-04		0 deg C 9-Nov-04		50 deg C 9-Nov-04		23 deg C 9-Nov-04	
Input	Output	Correction	Output	Correction	Output	Correction	Output	Correction	Output	Correction	Output	Correction	Output	Correction
4.000	4.0101	-0.010	4.0109	-0.011	4.0042	-0.004	4.0092	-0.009	4.0115	-0.011	4.0155	-0.016	4.0131	-0.013
6.000	6.0095	-0.010	6.0106	-0.011	6.0044	-0.004	6.0089	-0.009	6.0119	-0.012	6.0174	-0.017	6.0106	-0.011
8.000	8.0100	-0.010	8.0104	-0.010	8.0050	-0.005	8.0056	-0.006	8.0111	-0.011	8.0184	-0.018	8.0094	-0.009
10.000	10.0101	-0.010	10.0101	-0.010	10.0061	-0.006	10.0056	-0.006	10.0090	-0.009	10.0205	-0.021	10.0103	-0.010
12.000	12.0096	-0.010	12.0096	-0.010	12.0070	-0.007	12.0048	-0.005	12.0067	-0.007	12.0216	-0.022	12.0093	-0.009
14.000	14.0094	-0.009	14.0090	-0.009	14.0072	-0.007	14.0038	-0.004	14.0035	-0.004	14.0211	-0.021	14.0088	-0.009
16.000	16.0095	-0.009	16.0082	-0.008	16.0056	-0.006	16.0034	-0.003	16.0031	-0.003	16.0220	-0.022	16.0092	-0.009
18.000	18.0071	-0.007	18.0073	-0.007	18.0051	-0.005	18.0011	-0.001	18.0023	-0.002	18.0217	-0.022	18.0080	-0.008
20.000	20.0074	-0.007	20.0067	-0.007	20.0044	-0.004	20.0021	-0.002	20.0020	-0.002	20.0228	-0.023	20.0084	-0.008
22.000	22.0074	-0.007	22.0064	-0.006	22.0022	-0.002	22.0003	0.000	22.0016	-0.002	22.0216	-0.022	22.0072	-0.007
24.000	24.0067	-0.007	24.0061	-0.006	24.0041	-0.004	24.0008	-0.001	24.0006	-0.001	24.0229	-0.023	24.0078	-0.008
26.000	26.0071	-0.007	26.0056	-0.006	26.0022	-0.002	26.0007	-0.001	26.0004	0.000	26.0222	-0.022	26.0071	-0.007
28.000	28.0066	-0.007	28.0047	-0.005	28.0018	-0.002	28.0001	0.000	27.9994	0.001	28.0232	-0.023	28.0066	-0.007
30.000	30.0065	-0.006	30.0045	-0.005	29.9999	0.000	30.0007	-0.001	29.9997	0.000	30.0235	-0.023	30.0066	-0.007

Notes:
1. Dual Sonix digital pressure encoder serial number 14 was installed in pacer system 2.
2. Input, Output, and Correction are pressures measured in inches of Mercury.
3. The calibration tests were performed on the specified dates.
4. The Dual Sonix was soaked at the specified temperature in the environmental chamber for at least 2 hours prior to taking readings.
5. Power was on Dual Sonix unit throughout the testing.
6. A Ruska 6610 with an accuracy of approximately ±0.001 inches of mercury was used to provide the reference pressures.

Table C5 Instrument-Error Corrections to be Added to the Dual Sonix Indicated Total Pressure - System 1

	23 deg C 17-Sep-03		23 deg C 5-Nov-04		-55 deg C 8-Nov-04		-25 deg C 8-Nov-04		0 deg C 9-Nov-04		50 deg C 9-Nov-04		23 deg C 9-Nov-04	
Input	Output	Correction	Output	Correction	Output	Correction	Output	Correction	Output	Correction	Output	Correction	Output	Correction
5.000	4.9983	0.002	5.0000	0.000	4.9978	0.002	4.9948	0.005	4.9965	0.003	5.0071	-0.007	5.0024	-0.002
10.000	10.0018	-0.002	10.0023	-0.002	10.0001	0.000	9.9967	0.003	10.0007	-0.001	10.0146	-0.015	10.0074	-0.007
15.000	15.0053	-0.005	15.0045	-0.005	15.0003	0.000	15.0022	-0.002	15.0041	-0.004	15.0216	-0.022	15.0111	-0.011
20.000	20.0071	-0.007	20.0077	-0.008	20.0034	-0.003	20.0027	-0.003	20.0053	-0.005	20.0241	-0.024	20.0125	-0.012
25.000	25.0076	-0.008	25.0073	-0.007	25.0051	-0.005	25.0036	-0.004	25.0068	-0.007	25.0282	-0.028	25.0144	-0.014
30.000	30.0104	-0.010	30.0123	-0.012	30.0075	-0.008	30.0066	-0.007	30.0095	-0.009	30.0337	-0.034	30.0199	-0.020
35.000	35.0140	-0.014	35.0143	-0.014	35.0114	-0.011	35.0087	-0.009	35.0121	-0.012	35.0374	-0.037	35.0223	-0.022
40.000	40.0137	-0.014	40.0133	-0.013	40.0173	-0.017	40.0092	-0.009	40.0121	-0.012	40.0371	-0.037	40.0218	-0.022
45.000	45.0157	-0.016	45.0161	-0.016	45.0154	-0.015	45.011	-0.011	45.0158	-0.016	45.0427	-0.043	45.0231	-0.023
50.000	50.0162	-0.016	50.0148	-0.015	50.0179	-0.018	50.0109	-0.011	50.0150	-0.015	50.0424	-0.042	50.0238	-0.024
55.000	55.0171	-0.017	55.0169	-0.017	55.0201	-0.020	55.0124	-0.012	55.0150	-0.015	55.0455	-0.045	55.0250	-0.025
60.000	60.0199	-0.020	60.0161	-0.016	60.0216	-0.022	60.0139	-0.014	60.0167	-0.017	60.0489	-0.049	60.0268	-0.027
65.000	65.0216	-0.022	65.0184	-0.018	65.0237	-0.024	65.0159	-0.016	65.0171	-0.017	65.0490	-0.049	65.0261	-0.026
70.000	70.0212	-0.021	70.0173	-0.017	70.0263	-0.026	70.015	-0.015	70.0182	-0.018	70.0512	-0.051	70.0287	-0.029
75.000	75.0200	-0.020	75.0188	-0.019	75.0292	-0.029	75.015	-0.015	75.0159	-0.016	75.0537	-0.054	75.0258	-0.026

Notes:
1. Dual Sonix digital pressure encoder serial number 8 was installed in pacer system 1.
2. Input, Output, and Correction are pressures measured in inches of Mercury.
3. The calibration tests were performed on the specified dates.
4. The Dual Sonix was soaked at the specified temperature in the environmental chamber for at least 2 hours prior to taking readings.
5. Power was on Dual Sonix unit throughout the testing.
6. A Ruska 6610 with an accuracy of approximately ±0.002 inches of mercury was used to provide the reference pressures.

Table C6 Instrument-Error Corrections to be Added to the Dual Sonix Indicated Total Pressure - System 2

	23 deg C 17-Sep-03		23 deg C 5-Nov-04		-55 deg C 8-Nov-04		-25 deg C 8-Nov-04		0 deg C 9-Nov-04		50 deg C 9-Nov-04		23 deg C 9-Nov-04	
Input	Output	Correction	Output	Correction	Output	Correction	Output	Correction	Output	Correction	Output	Correction	Output	Correction
5.000	4.9952	0.005	4.9926	0.007	4.9951	0.005	4.9920	0.008	4.9894	0.011	5.0026	-0.003	4.9965	0.003
10.000	9.9999	0.000	9.9967	0.003	9.9982	0.002	9.9942	0.006	9.9933	0.007	10.0124	-0.012	10.0012	-0.001
15.000	14.9999	0.000	14.9980	0.002	14.9980	0.002	14.9950	0.005	14.9967	0.003	15.0196	-0.020	15.0053	-0.005
20.000	20.0024	-0.002	20.0010	-0.001	19.9992	0.001	19.9981	0.002	19.9961	0.004	20.0263	-0.026	20.0065	-0.006
25.000	25.0051	-0.005	25.0020	-0.002	25.0005	0.000	24.9985	0.002	24.9976	0.002	25.0289	-0.029	25.0086	-0.009
30.000	30.0093	-0.009	30.0026	-0.003	30.0020	-0.002	30.0017	-0.002	30.0026	-0.003	30.0317	-0.032	30.0103	-0.010
35.000	35.0069	-0.007	35.0069	-0.007	35.0019	-0.002	34.0022	0.998	35.0024	-0.002	35.0362	-0.036	35.0140	-0.014
40.000	40.0087	-0.009	40.0066	-0.007	40.0039	-0.004	40.0037	-0.004	40.0016	-0.002	40.0403	-0.040	40.0151	-0.015
45.000	45.0109	-0.011	45.0053	-0.005	45.0054	-0.005	45.0035	-0.004	45.0028	-0.003	45.0446	-0.045	45.0166	-0.017
50.000	50.0102	-0.010	50.0059	-0.006	50.0029	-0.003	50.0039	-0.004	50.0026	-0.003	50.0443	-0.044	50.0142	-0.014
55.000	55.0108	-0.011	55.0072	-0.007	55.0055	-0.005	55.0038	-0.004	55.0023	-0.002	55.0460	-0.046	55.0159	-0.016
60.000	60.0105	-0.011	60.0040	-0.004	60.0018	-0.002	60.0038	-0.004	60.0001	0.000	60.0492	-0.049	60.0170	-0.017
65.000	65.0113	-0.011	65.0053	-0.005	65.0048	-0.005	65.0031	-0.003	34.9994	30.001	65.0530	-0.053	65.0176	-0.018
70.000	70.0131	-0.013	70.0077	-0.008	70.0030	-0.003	70.0050	-0.005	70.0001	0.000	70.0550	-0.055	70.0146	-0.015
75.000	75.0125	-0.013	75.0089	-0.009	75.0063	-0.006	75.0016	-0.002	75.0030	-0.003	75.0533	-0.053	75.0167	-0.017

Notes:
1. Dual Sonix digital pressure encoder serial number 14 was installed in pacer system 2.
2. Input, Output, and Correction are pressures measured in inches of Mercury.
3. The calibration tests were performed on the specified dates.
4. The Dual Sonix was soaked at the specified temperature in the environmental chamber for at least 2 hours prior to taking readings.
5. Power was on Dual Sonix unit throughout the testing.
6. A Ruska 6610 with an accuracy of approximately ±0.002 inches of mercury was used to provide the reference pressures.

Table C7 Pacer System 1 Static Source Error Correction Curve

Instrument-Corrected Mach Number (n/d)	Static Source Error Correction Curve	
	Slope, *m* (1/degree)	Intercept, *b* (n/d)
0.000	-0.000094	-0.016300
0.500	-0.000094	-0.016300
0.550	0.000543	-0.016300
0.600	0.000817	-0.015800
0.650	0.000866	-0.014700
0.750	0.000796	-0.011161
0.800	0.000900	-0.009750
0.825	0.001031	-0.009250
0.875	0.001506	-0.008400
0.910	0.002043	-0.008500
0.925	0.002333	-0.009200
0.935	0.002546	-0.010200
0.945	0.002778	-0.011400
0.950	0.002900	-0.014700
1.000	0.002900	-0.014700

Notes: 1. The equation for the static source error correction coefficient was:

$\Delta P_{pc}(M_{ic}, \alpha_i)/q_{cic} = m(M_{ic})\, \alpha_i + b(M_{ic})$

where:

$\Delta P_{pc}/q_{cic}$ = Static source error correction coefficient.

M_{ic} = Instrument-corrected Mach number.

m = slope of the static source error correction equation.

b = intercept of the static source error correction equation.

α_i = indicated angle of attack.

2. F-16B USAF S/N 92-0457.

3. Flaps and landing gear retracted. Advanced range data system pod on station 1, 370-gallon fuel tanks on stations 4 and 6.

4. The slopes and intercepts were given with extra significant digits to provide for a smooth curve.

5. n/d - nondimensional

Table C8 Pressure Altitudes and Ambient Air Temperatures for the Tower Flyby Test Points - 7 April 2004

Time (local)	Pressure Altitude at the Zero Grid Line (ft)	Pressure Altitude from the Least Squares Equation (ft)	Difference Squared (ft^2)	Ambient Air Temperature at the Zero Grid Line (deg F)	Ambient Air Temperature from the Least Squares Equation (deg F)	Difference Squared (deg F^2)
6:59	2,237	2,236	2	46.1	45.8	0.1
7:04	2,235	2,235	0	46.3	46.2	0.0
7:09	2,235	2,234	1	46.6	46.6	0.0
7:14	2,233	2,234	1	46.9	47.0	0.0
7:19	2,235	2,233	3	47.4	47.5	0.0
7:24	2,231	2,232	0	48.0	47.9	0.0
7:29	2,230	2,231	1	48.5	48.4	0.0
7:34	2,230	2,231	1	48.9	48.9	0.0
7:39	2,230	2,230	0	49.3	49.3	0.0
7:44	2,230	2,229	0	49.8	49.8	0.0
7:49	2,229	2,228	0	50.3	50.4	0.0
7:54	2,226	2,228	1	50.7	50.9	0.0
7:59	2,226	2,227	0	51.3	51.4	0.0
8:04	2,225	2,226	1	51.9	52.0	0.0
8:09	2,225	2,225	0	52.3	52.5	0.1
8:14	2,224	2,225	1	53.0	53.1	0.0
8:19	2,222	2,224	2	54.0	53.7	0.1
8:24	2,223	2,223	0	54.4	54.3	0.0
8:29	2,222	2,222	0	55.2	54.9	0.1
8:34	2,221	2,221	0	55.9	55.6	0.1
8:39	2,221	2,221	0	56.3	56.2	0.0
8:44	2,222	2,220	2	56.7	56.9	0.0
8:49	2,222	2,219	5	57.3	57.5	0.1
8:54	2,223	2,218	20	58.2	58.2	0.0
8:59	2,224	2,218	45	59.0	58.9	0.0
9:04	2,225	2,217	70	60.2	59.6	0.3
9:09	2,226	2,216	89	60.4	60.4	0.0
9:14	2,224	2,215	76	61.0	61.1	0.0
9:19	2,224	2,215	95	62.0	61.9	0.0
9:24	2,234	2,214	420	62.2	62.6	0.2
ν	29	SEE	6		SEE	0.2
t	2.045	$t \times$ SEE	11		$t \times$ SEE	0.4

Notes:
1. The tower flyby passes were between 7:37 and 8:53 local.
2. ν - number of degrees of freedom.
3. t - Student's t statistic for 95 percent confidence.
4. SEE - Standard error of estimate.
5. The least squares regression equation used for the pressure altitude was (altitude) = -218.8103(Excel time) + 2299.6
6. The least squares regression equation used for the ambient air temperature was (temperature) = 549.36*(Excel time)^2 - 208.21(Excel time) + 59.9
7. The pressure altitude was measured using a Setra model 370 digital pressure gauge, serial number 2017712.
8. The ambient air temperature was measured using an Omega model HH-41 thermometer, serial number 304812, with a model ON-405-PP air temperature probe.

Table C9 Pressure Altitudes and Ambient Air Temperatures for the Tower Flyby Test Points - 12 April 2004

Time (local)	Pressure Altitude at the Zero Grid Line (ft)	Pressure Altitude from the Least Squares Equation (ft)	Difference Squared (ft^2)	Ambient Air Temperature at the Zero Grid Line (deg F)	Ambient Air Temperature from the Least Squares Equation (deg F)	Difference Squared (deg F^2)
7:00	2,183	2,182	1	47.3	46.9	0.2
7:05	2,182	2,181	2	47.0	47.1	0.0
7:10	2,181	2,180	0	46.8	47.3	0.3
7:15	2,180	2,179	0	47.0	47.6	0.4
7:20	2,178	2,178	0	47.4	47.8	0.2
7:25	2,178	2,178	1	48.1	48.1	0.0
7:30	2,177	2,177	0	48.6	48.4	0.0
7:35	2,175	2,176	1	49.0	48.8	0.0
7:40	2,174	2,175	2	49.9	49.1	0.7
7:45	2,174	2,174	0	50.3	49.4	0.7
7:50	2,173	2,173	0	50.1	49.8	0.1
7:55	2,172	2,172	0	50.3	50.2	0.0
8:00	2,171	2,171	0	50.5	50.6	0.0
8:05	2,169	2,171	3	51.1	51.0	0.0
8:10	2,168	2,170	4	51.3	51.5	0.0
8:15	2,168	2,169	1	51.6	51.9	0.1
8:20	2,168	2,168	0	52.2	52.4	0.0
8:25	2,167	2,167	0	52.7	52.9	0.0
8:30	2,166	2,166	0	53.6	53.4	0.0
8:35	2,165	2,165	0	54.1	53.9	0.0
8:40	2,164	2,164	0	54.3	54.4	0.0
8:45	2,164	2,164	1	55.0	54.9	0.0
8:50	2,164	2,163	3	55.0	55.5	0.2
8:55	2,164	2,162	4	55.6	56.1	0.3
9:00	2,165	2,161	17	56.4	56.7	0.1
9:05	2,165	2,160	25	57.1	57.3	0.0
9:10	2,165	2,159	34	57.3	57.9	0.3
9:15	2,164	2,158	34	59.3	58.6	0.6
9:20	2,162	2,157	25	60.0	59.2	0.5
ν	28	SEE	2		SEE	0.4
t	2.048	$t \times$ SEE	5		$t \times$ SEE	0.9

Notes:
1. The tower flyby passes were between 7:34 and 8:52 local.
2. ν - number of degrees of freedom.
3. t - Student's t statistic for 95 percent confidence.
4. SEE - Standard error of estimate.
5. The least squares regression equation used for the pressure altitude was (altitude) = -252.906(Excel time) + 2255.8
6. The least squares regression equation used for the ambient air temperature was (temperature) = 674.53*(Excel time)^2 - 332.21(Excel time) + 86.3
7. The pressure altitude was measured using a Setra model 370 digital pressure gauge, serial number 2017712.
8. The ambient air temperature was measured using an Omega model HH-41 thermometer, serial number 304812, with a model ON-405-PP air temperature probe.

Table C10 Pressure Altitudes and Ambient Air Temperatures for the Tower Flyby Test Points - 13 April 2004

Time (local)	Pressure Altitude at the Zero Grid Line (ft)	Pressure Altitude from the Least Squares Equation (ft)	Difference Squared (ft^2)	Ambient Air Temperature at the Zero Grid Line (deg F)	Ambient Air Temperature from the Least Squares Equation (deg F)	Difference Squared (deg F^2)
6:55	2,207	2,209	3	51.6	51.0	0.3
7:00	2,208	2,207	0	52.6	51.4	1.3
7:05	2,207	2,206	1	51.9	51.9	0.0
7:10	2,205	2,205	0	51.6	52.3	0.5
7:15	2,205	2,204	2	52.5	52.8	0.1
7:20	2,205	2,203	6	53.4	53.2	0.0
7:25	2,203	2,202	3	53.1	53.7	0.4
7:30	2,202	2,201	1	53.1	54.1	1.1
7:35	2,199	2,200	0	53.8	54.6	0.6
7:40	2,196	2,199	6	54.5	55.0	0.3
7:45	2,194	2,198	14	55.2	55.4	0.0
7:50	2,194	2,197	9	55.9	55.9	0.0
7:55	2,194	2,197	6	56.7	56.3	0.1
8:00	2,195	2,196	2	57.4	56.7	0.4
8:05	2,196	2,196	1	57.9	57.2	0.5
8:10	2,196	2,195	1	58.5	57.6	0.8
8:15	2,197	2,195	3	58.5	58.1	0.2
8:20	2,196	2,195	3	58.7	58.5	0.1
8:25	2,196	2,194	1	59.0	58.9	0.0
8:30	2,194	2,194	0	59.4	59.3	0.0
8:35	2,194	2,194	0	59.1	59.8	0.5
8:40	2,194	2,194	0	59.5	60.2	0.5
8:45	2,195	2,194	1	60.8	60.6	0.0
8:50	2,195	2,194	0	60.7	61.0	0.1
8:55	2,194	2,195	0	61.7	61.5	0.1
9:00	2,195	2,195	0	62.2	61.9	0.1
9:05	2,195	2,195	0	62.2	62.3	0.0
9:10	2,196	2,196	0	62.8	62.7	0.0
9:15	2,198	2,196	2	63.3	63.2	0.0
9:20	2,197	2,197	0	63.8	63.6	0.1
9:25	2,196	2,197	1	63.6	64.0	0.2
9:30	2,196	2,198	5	64.4	64.4	0.0
ν	31	SEE	2		SEE	0.5
t	2.039	$t \times$ SEE	3		$t \times$ SEE	1.1

Notes: 1. The tower flyby passes were between 7:31 and 8:57 local.
2. ν - number of degrees of freedom.
3. t - Student's t statistic for 95 percent confidence.
4. SEE - Standard error of estimate.
5. The least squares regression equation used for the pressure altitude was (altitude) = $2854.113(\text{Excel time})^2 - 2054.325(\text{Excel time}) + 2563.8$
6. The least squares regression equation used for the ambient air temperature was (temperature) = $-41.739(\text{Excel time})^2 + 153.28(\text{Excel time}) + 10.3$
7. The pressure altitude was measured using a Setra model 370 digital pressure gauge, serial number 2017712
8. The ambient air temperature was measured using an Omega model HH-41 thermometer, serial number 304812, with a model ON-405-PP air temperature probe.

Table C11 Pressure Altitudes and Ambient Air Temperatures for the Tower Flyby Test Points - 30 April 2004

Time (local)	Pressure Altitude at the Zero Grid Line (ft)	Pressure Altitude from the Least Squares Equation (ft)	Difference Squared (ft^2)	Ambient Air Temperature at the Zero Grid Line (deg F)	Ambient Air Temperature from the Least Squares Equation (deg F)	Difference Squared (deg F^2)
6:30	2,147	2,146	2	49.0	49.0	0.0
6:35	2,145	2,144	1	49.9	49.9	0.0
6:40	2,143	2,142	1	50.6	50.6	0.0
6:46	2,141	2,140	1	50.7	51.0	0.1
6:50	2,139	2,139	0	50.8	51.2	0.2
6:55	2,135	2,137	2	50.8	51.2	0.1
7:00	2,134	2,135	1	51.2	51.0	0.0
7:05	2,132	2,133	2	51.6	50.8	0.6
7:10	2,131	2,131	0	51.2	50.6	0.3
7:15	2,128	2,129	2	51.2	50.3	0.8
7:20	2,127	2,128	1	50.3	50.1	0.0
7:25	2,125	2,126	2	47.8	50.0	4.7
7:30	2,122	2,124	3	48.5	50.0	2.1
7:35	2,122	2,122	0	49.5	50.1	0.3
7:40	2,122	2,120	3	50.9	50.4	0.2
7:45	2,120	2,118	2	52.4	51.0	1.8
7:50	2,116	2,117	0	52.8	51.9	0.9
7:55	2,115	2,115	0	52.9	53.1	0.0
8:00	2,115	2,113	5	53.8	54.7	0.8
ν	18	SEE	1		SEE	1.0
t	2.101	*t* × SEE	3		*t* × SEE	2.0

Notes: 1. The tower flyby passes were between 7:22 and 7:31 local.
2. ν - number of degrees of freedom.
3. *t* - Student's *t* statistic for 95 percent confidence.
4. SEE - Standard error of estimate.
5. The least squares regression equation used for the pressure altitude was (altitude) = -531.3514(Excel time) + 2289.9
6. The least squares regression equation used for the ambient air temperature was (temperature) = 164175(Excel time)^3 - 147246(Excel time)^2 + 43946(Excel time) - 4313.9
7. The pressure altitude was measured using a Setra model 370 digital pressure gauge, serial number 2017712.
8. The ambient air temperature was measured using an Omega model HH-41 thermometer, serial number 304812, with a model ON-405-PP air temperature probe.

Table C12 Pressure Altitudes and Ambient Air Temperatures for the Tower Flyby Test Points - 23 November 2004

Time (local)	Pressure Altitude at the Zero Grid Line (ft)	Pressure Altitude from the Least Squares Equation (ft)	Difference Squared (ft^2)	Ambient Air Temperature at the Zero Grid Line (deg F)	Ambient Air Temperature from the Least Squares Equation (deg F)	Difference Squared (deg F^2)
7:12	2,171	2,171	0	30.2	30.3	0.0
7:15	2,174	2,171	12	30.0	30.5	0.2
7:20	2,171	2,170	1	30.3	30.8	0.3
7:25	2,167	2,169	6	30.3	31.1	0.7
7:30	2,163	2,169	33	30.5	31.5	1.0
7:35	2,164	2,168	17	31.3	31.8	0.3
7:40	2,163	2,168	21	31.4	32.2	0.6
7:45	2,170	2,167	9	32.4	32.5	0.0
7:50	2,170	2,166	13	34.0	32.8	1.3
7:55	2,172	2,166	39	33.9	33.2	0.5
8:00	2,171	2,165	35	34.7	33.5	1.4
8:05	2,167	2,165	6	34.6	33.9	0.6
8:10	2,170	2,164	37	35.6	34.2	1.8
8:15	2,168	2,163	22	35.9	34.5	1.7
8:20	2,164	2,163	2	35.8	34.9	0.8
8:25	2,166	2,162	15	36.5	35.2	1.5
8:30	2,166	2,161	20	36.9	35.6	1.8
8:35	2,163	2,161	5	37.1	35.9	1.5
8:40	2,163	2,160	7	36.6	36.2	0.1
8:45	2,161	2,160	2	36.6	36.6	0.0
8:50	2,157	2,159	4	36.3	36.9	0.4
8:55	2,155	2,158	12	35.7	37.3	2.4
9:00	2,155	2,158	8	36.5	37.6	1.2
9:05	2,152	2,157	27	37.1	37.9	0.7
9:10	2,151	2,157	32	37.8	38.3	0.2
9:15	2,148	2,156	64	38.1	38.6	0.3
9:20	2,149	2,155	41	38.4	39.0	0.3
9:25	2,147	2,155	61	38.7	39.3	0.4
9:30	2,143	2,154	126	38.7	39.6	1.0
9:35	2,144	2,154	92	39.3	40.0	0.4
9:40	2,148	2,153	25	39.8	40.3	0.2
9:45	2,147	2,152	29	39.0	40.7	2.9
9:50	2,144	2,152	61	39.4	41.0	2.5
9:55	2,149	2,151	5	40.6	41.3	0.5
10:00	2,153	2,151	6	41.4	41.7	0.1

Table C12 Pressure Altitudes and Ambient Air Temperatures for the Tower Flyby Test Points - 23 November 2004 (Concluded)

Time (local)	Pressure Altitude at the Zero Grid Line (ft)	Pressure Altitude from the Least Squares Equation (ft)	Difference Squared (ft^2)	Ambient Air Temperature at the Zero Grid Line (deg F)	Ambient Air Temperature from the Least Squares Equation (deg F)	Difference Squared (deg F^2)
10:05	2,156	2,150	36	42.5	42.0	0.3
10:10	2,157	2,149	58	43.1	42.4	0.6
10:15	2,158	2,149	86	43.1	42.7	0.1
10:20	2,156	2,148	62	44.3	43.0	1.6
10:25	2,154	2,148	42	44.7	43.4	1.6
10:30	2,153	2,147	37	45.1	43.7	2.0
ν	40	SEE	6		SEE	1.0
t	2.021	*t* × SEE	11		*t* × SEE	1.9

Notes: 1. The tower flyby passes were between 8:25 and 9:53 local.
2. ν - number of degrees of freedom.
3. *t* - Student's *t* statistic for 95 percent confidence.
4. SEE - Standard error of estimate.
5. The least squares regression equation used for the pressure altitude was (altitude) = -174.55(Excel time) + 2223.3
6. The least squares regression equation used for the ambient air temperature was (temperature) = 97.897(Excel time) + 0.9
7. The pressure altitude was measured using a NovaLynx 230-355 handheld barometer, serial number 967820-S2.
8. The ambient air temperature was measured using an Omega model HH-41 thermometer, serial number 304812, with a model ON-405-PP air temperature probe.

Table C13 Pressure Altitude at the Test Aircraft for the Tower Flyby Test Points

Flight Date	Time (local)	Pressure Altitude at the Zero Grid Line (ft)	Recorded Grid Reading (n/d)	Ambient Temperature at the Zero Grid Line (K)	Calculated Pressure Altitude of Aircraft Based on Tower Flyby Readings (ft)
7-Apr-04	7:37:35	2,227	2.8	282.7	2,316
7-Apr-04	7:42:10	2,226	3.5	283.0	2,337
7-Apr-04	7:46:12	2,226	3.3	283.2	2,330
7-Apr-04	7:50:00	2,225	3.1	283.4	2,323
7-Apr-04	7:53:37	2,225	3.0	283.6	2,319
7-Apr-04	7:57:12	2,224	2.2	283.8	2,293
7-Apr-04	8:00:42	2,224	2.6	284.0	2,305
7-Apr-04	8:04:43	2,223	3.0	284.3	2,317
7-Apr-04	8:08:32	2,222	3.1	284.5	2,320
7-Apr-04	8:12:28	2,222	2.5	284.8	2,300
7-Apr-04	8:16:15	2,221	2.0	285.0	2,284
7-Apr-04	8:20:47	2,220	2.5	285.3	2,299
7-Apr-04	8:25:36	2,220	2.1	285.7	2,285
7-Apr-04	8:30:12	2,219	2.9	286.0	2,310
7-Apr-04	8:34:54	2,218	3.4	286.3	2,324
7-Apr-04	8:39:39	2,218	3.5	286.7	2,327
7-Apr-04	8:44:23	2,217	2.7	287.0	2,301
7-Apr-04	8:48:36	2,216	2.6	287.3	2,297
7-Apr-04	8:52:43	2,216	2.3	287.6	2,287
12-Apr-04	7:34:13	2,173	1.4	282.4	2,217
12-Apr-04	7:38:13	2,172	1.3	282.6	2,213
12-Apr-04	7:41:59	2,172	1.6	282.7	2,222
12-Apr-04	7:45:31	2,171	1.2	282.8	2,209
12-Apr-04	7:48:55	2,170	1.9	283.0	2,230
12-Apr-04	7:52:19	2,170	1.7	283.1	2,224
12-Apr-04	7:55:32	2,169	2.2	283.3	2,239
12-Apr-04	7:58:40	2,169	2.0	283.4	2,232
12-Apr-04	8:01:45	2,168	2.2	283.5	2,238
12-Apr-04	8:04:49	2,168	2.2	283.7	2,237
12-Apr-04	8:08:02	2,167	2.1	283.8	2,233
12-Apr-04	8:11:13	2,167	2.1	284.0	2,233
12-Apr-04	8:15:09	2,166	1.4	284.2	2,210
12-Apr-04	8:19:11	2,165	2.1	284.4	2,231
12-Apr-04	8:23:19	2,164	1.7	284.6	2,218
12-Apr-04	8:27:41	2,164	2.3	284.9	2,236
12-Apr-04	8:32:30	2,163	1.9	285.1	2,222
12-Apr-04	8:37:14	2,162	1.9	285.4	2,221
12-Apr-04	8:41:25	2,161	1.4	285.6	2,205
12-Apr-04	8:46:17	2,160	1.7	285.9	2,214
12-Apr-04	8:51:24	2,159	2.2	286.3	2,228

Table C13 Pressure Altitude at the Test Aircraft for the Tower Flyby Test Points (Continued)

Flight Date	Time (local)	Pressure Altitude at the Zero Grid Line (ft)	Recorded Grid Reading (n/d)	Ambient Temperature at the Zero Grid Line (K)	Calculated Pressure Altitude of Aircraft Based on Tower Flyby Readings (ft)
13-Apr-04	7:31:12	2,197	2.2	285.5	2,266
13-Apr-04	7:35:08	2,197	2.3	285.7	2,269
13-Apr-04	7:38:46	2,196	2.2	285.9	2,265
13-Apr-04	7:42:20	2,195	2.4	286.0	2,270
13-Apr-04	7:45:42	2,195	2.1	286.2	2,261
13-Apr-04	7:48:54	2,195	2.0	286.4	2,257
13-Apr-04	7:52:21	2,194	2.5	286.5	2,272
13-Apr-04	7:55:35	2,194	2.4	286.7	2,268
13-Apr-04	7:58:54	2,193	2.6	286.8	2,274
13-Apr-04	8:02:26	2,193	2.2	287.0	2,261
13-Apr-04	8:05:56	2,193	2.4	287.2	2,267
13-Apr-04	8:09:25	2,192	1.9	287.3	2,251
13-Apr-04	8:13:24	2,192	2.1	287.5	2,257
13-Apr-04	8:17:30	2,192	1.8	287.7	2,248
13-Apr-04	8:21:41	2,192	2.5	287.9	2,269
13-Apr-04	8:26:18	2,191	2.2	288.2	2,260
13-Apr-04	8:31:13	2,191	2.2	288.4	2,259
13-Apr-04	8:36:04	2,191	2.5	288.6	2,269
13-Apr-04	8:40:17	2,191	2.5	288.8	2,269
13-Apr-04	8:44:14	2,191	2.2	289.0	2,259
13-Apr-04	8:48:12	2,191	2.1	289.2	2,256
13-Apr-04	8:53:07	2,191	3.0	289.4	2,284
13-Apr-04	8:56:38	2,192	2.4	289.6	2,266
30-Apr-04	7:22:18	2,124	2.0	283.2	2,187
30-Apr-04	7:25:44	2,122	3.0	283.1	2,217
30-Apr-04	7:30:04	2,121	2.0	283.1	2,184
23-Nov-04	8:25:50	2,162	2.7	275.0	2,250
23-Nov-04	8:29:38	2,162	3.3	275.0	2,269
23-Nov-04	8:32:53	2,162	3.5	275.0	2,275
23-Nov-04	8:36:33	2,161	2.8	275.1	2,252
23-Nov-04	9:18:36	2,161	3.8	275.2	2,284
23-Nov-04	9:23:23	2,156	3.3	275.4	2,263
23-Nov-04	9:27:45	2,155	3.5	277.0	2,268
23-Nov-04	9:31:39	2,154	3.2	277.1	2,258
23-Nov-04	9:34:54	2,154	2.8	277.3	2,244
23-Nov-04	9:38:19	2,154	3.1	277.5	2,253
23-Nov-04	9:42:00	2,153	3.0	277.6	2,250
23-Nov-04	9:45:35	2,153	3.0	277.7	2,249

Table C13 Pressure Altitude at the Test Aircraft for the Tower Flyby Test Points (Concluded)

Flight Date	Time (local)	Pressure Altitude at the Zero Grid Line (ft)	Recorded Grid Reading (n/d)	Ambient Temperature at the Zero Grid Line (K)	Calculated Pressure Altitude of Aircraft Based on Tower Flyby Readings (ft)
23-Nov-04	9:48:56	2,152	3.3	277.9	2,258
23-Nov-04	9:52:08	2,152	3.0	278.0	2,248

Note: The calculated actual pressure altitude of the aircraft was:

$$H_{\mathrm{p,aircraft}} = H_{\mathrm{p,0}} + \Delta h \frac{T_{a,\mathrm{std}}}{T_{a,\mathrm{t}}}$$

where:

$H_{\mathrm{p,aircraft}}$ = pressure altitude at the aircraft

$H_{\mathrm{p,0}}$ = pressure altitude measured at the zero grid line

Δh = geometric height between the zero grid line and the aircraft, equal to 31.48 times the grid reading

$T_{a,\mathrm{std}}$ = standard day ambient air temperature at the zero grid line

$T_{\mathrm{a,t}}$ = test day ambient air temperature at the zero grid line

Table C14 Pacer System 1 Air Data from the Tower Flyby Test Points

Flight Date	Time (local)	Instrument-Corrected Pressure Altitude (ft)	Instrument-Corrected Airspeed (kt)	Instrument-Corrected Mach Number (n/d)	Indicated Angle of Attack (deg)	Total Air Temperature (K)
7-Apr-04	7:37:35	2,243	296.3	0.4656	4.8	293.0
7-Apr-04	7:42:10	2,247	326.5	0.5130	4.2	295.9
7-Apr-04	7:46:12	2,241	337.2	0.5296	3.7	297.1
7-Apr-04	7:50:00	2,222	377.6	0.5926	2.9	301.2
7-Apr-04	7:53:37	2,205	391.4	0.6140	2.7	302.9
7-Apr-04	7:57:12	2,172	419.4	0.6573	2.4	305.6
7-Apr-04	8:00:42	2,174	445.1	0.6972	2.0	308.2
7-Apr-04	8:04:43	2,191	502.3	0.7862	1.5	315.4
7-Apr-04	8:08:32	2,192	510.4	0.7989	1.4	316.6
7-Apr-04	8:12:28	2,182	554.6	0.8672	1.2	322.6
7-Apr-04	8:16:15	2,163	560.9	0.8767	1.1	324.0
7-Apr-04	8:20:47	2,237	267.3	0.4202	5.2	293.3
7-Apr-04	8:25:36	2,235	243.5	0.3829	6.3	291.9
7-Apr-04	8:30:12	2,278	196.0	0.3086	9.4	288.9
7-Apr-04	8:34:54	2,299	175.6	0.2765	11.6	288.3
7-Apr-04	8:39:39	2,294	182.2	0.2869	10.7	288.8
7-Apr-04	8:44:23	2,252	228.8	0.3599	6.7	291.8
7-Apr-04	8:48:36	2,215	325.3	0.5108	3.1	299.1
7-Apr-04	8:52:43	2,160	473.1	0.7405	1.5	314.3
12-Apr-04	7:34:13	2,140	299.3	0.4696	5.3	293.4
12-Apr-04	7:38:13	2,131	324.7	0.5092	3.8	295.6
12-Apr-04	7:41:59	2,128	347.1	0.5440	3.5	298.1
12-Apr-04	7:45:31	2,107	371.9	0.5825	2.9	300.6
12-Apr-04	7:48:55	2,118	395.0	0.6186	2.5	303.1
12-Apr-04	7:52:19	2,109	423.3	0.6625	2.1	305.2
12-Apr-04	7:55:32	2,117	444.1	0.6951	1.8	308.7
12-Apr-04	7:58:40	2,104	471.3	0.7372	1.5	311.6
12-Apr-04	8:01:45	2,108	495.2	0.7742	1.4	314.1
12-Apr-04	8:04:49	2,115	521.4	0.8150	1.2	317.4
12-Apr-04	8:08:02	2,113	545.3	0.8519	1.0	320.6
12-Apr-04	8:11:13	2,115	575.0	0.8979	1.0	324.7
12-Apr-04	8:15:09	2,147	275.0	0.4316	4.7	292.6
12-Apr-04	8:19:11	2,178	250.6	0.3936	5.6	290.9
12-Apr-04	8:23:19	2,178	225.0	0.3535	6.9	289.4
12-Apr-04	8:27:41	2,199	199.8	0.3141	8.3	288.4
12-Apr-04	8:32:30	2,195	188.7	0.2966	9.3	287.8
12-Apr-04	8:37:14	2,196	180.9	0.2845	9.7	287.4
12-Apr-04	8:41:25	2,131	299.3	0.4694	3.5	295.6
12-Apr-04	8:46:17	2,188	179.4	0.2820	9.6	287.8
12-Apr-04	8:51:24	2,207	172.2	0.2708	10.1	287.8
13-Apr-04	7:31:12	2,192	303.2	0.4760	4.7	297.1

Table C14 Pacer System 1 Air Data from the Tower Flyby Test Points (Continued)

Flight Date	Time (local)	Instrument-Corrected Pressure Altitude (ft)	Instrument-Corrected Airspeed (kt)	Instrument-Corrected Mach Number (n/d)	Indicated Angle of Attack (deg)	Total Air Temperature (K)
13-Apr-04	7:35:08	2,184	329.4	0.5169	3.8	299.5
13-Apr-04	7:38:46	2,165	363.2	0.5696	3.1	303.2
13-Apr-04	7:42:20	2,166	377.6	0.5920	2.7	304.4
13-Apr-04	7:45:42	2,146	409.1	0.6409	2.4	307.3
13-Apr-04	7:48:54	2,139	425.7	0.6667	2.1	309.2
13-Apr-04	7:52:21	2,146	441.9	0.6919	2.0	310.9
13-Apr-04	7:55:35	2,140	469.3	0.7345	1.7	314.4
13-Apr-04	7:58:54	2,145	496.6	0.7769	1.3	318.0
13-Apr-04	8:02:26	2,138	523.1	0.8179	1.2	321.5
13-Apr-04	8:05:56	2,151	551.6	0.8621	1.1	325.7
13-Apr-04	8:09:25	2,131	579.9	0.9057	1.0	330.1
13-Apr-04	8:13:24	2,195	274.5	0.4312	4.6	296.2
13-Apr-04	8:17:30	2,199	250.2	0.3931	5.6	294.5
13-Apr-04	8:21:41	2,223	223.8	0.3519	7.0	293.0
13-Apr-04	8:26:18	2,227	199.4	0.3136	8.8	291.8
13-Apr-04	8:31:13	2,232	181.5	0.2855	10.0	290.9
13-Apr-04	8:36:04	2,237	190.6	0.2999	9.2	291.5
13-Apr-04	8:40:17	2,191	298.5	0.4686	3.5	299.1
13-Apr-04	8:44:14	2,175	324.2	0.5087	2.9	301.8
13-Apr-04	8:48:12	2,193	274.9	0.4317	4.2	297.4
13-Apr-04	8:53:07	2,261	172.3	0.2713	10.7	291.1
13-Apr-04	8:56:38	2,136	451.6	0.7069	1.2	314.6
30-Apr-04	7:22:18	2,113	306.8	0.4810	4.5	295.1
30-Apr-04	7:25:44	2,095	496.5	0.7761	1.5	315.3
30-Apr-04	7:30:04	2,150	205.8	0.3232	9.6	288.0
23-Nov-04	8:25:50	2,164	347.0	0.5442	3.4	291.3
23-Nov-04	8:29:38	2,155	448.4	0.7021	1.6	301.5
23-Nov-04	8:32:53	2,160	545.4	0.8527	1.0	314.3
23-Nov-04	8:36:33	2,185	301.3	0.4730	4.3	287.3
23-Nov-04	9:18:36	2,245	197.4	0.3105	9.2	280.9
23-Nov-04	9:23:23	2,238	182.5	0.2872	10.7	280.5
23-Nov-04	9:27:45	2,211	250.2	0.3933	5.5	284.3
23-Nov-04	9:31:39	2,144	402.4	0.6304	1.9	297.8
23-Nov-04	9:34:54	2,127	581.3	0.9078	1.3	321.4
23-Nov-04	9:38:19	2,165	350.2	0.5492	2.5	293.2
23-Nov-04	9:42:00	2,140	395.8	0.6201	1.8	297.2
23-Nov-04	9:45:35	2,132	448.3	0.7016	1.3	302.9

Table C14 Pacer System 1 Air Data from the Tower Flyby Test Points (Concluded)

Flight Date	Time (local)	Instrument-Corrected Pressure Altitude (ft)	Instrument-Corrected Airspeed (kts)	Instrument-Corrected Mach Number (n/d)	Indicated Angle of Attack (deg)	Total Air Temperature (K)
23-Nov-04	9:48:56	2,134	493.5	0.7719	0.9	309.0
23-Nov-04	9:52:08	2,124	519.3	0.8117	0.8	313.1

Notes: 1. System 1 used Dual Sonix digital pressure encoder serial number 8.

2. The static and total pressures from the Dual Sonix were corrected for instrument errors. Pressure altitude, airspeed, and Mach number were calculated using instrument-corrected static and total pressures.

3. The total air temperatures listed for the 7, 12, 13, and 30 April 2004 flights were measured using the flight test total temperature probe, serial number 1187.

4. The total air temperatures listed for the 30 November 2004 flight were measured using the production aircraft total temperature probe.

5. The angle of attack was measured by the production aircraft angle of attack system.

6. The flaps and landing gear were retracted. ARDS pod on station 1, 370 gallon fuel tanks on stations 4 and 6.

7. F-16B USAF serial number 92-0457.

Table C15 Pacer System 1 Static Source Error Corrections from the Tower Flyby Test Points

Flight Date	Time (local)	Indicated Angle of Attack (deg)	Instrument-Corrected Mach Number (n/d)	Instrument-Corrected Pressure Altitude (ft)	Static Source Error Corrections Altitude, ΔH_{pc} (ft)	Static Source Error Corrections Pressure, $\Delta P_{pc}/q_{cic}$ (n/d)
7-Apr-04	7:37:35	4.8	0.4656	2,243	72	-0.0166
7-Apr-04	7:42:10	4.2	0.5130	2,247	90	-0.0168
7-Apr-04	7:46:12	3.7	0.5296	2,241	89	-0.0155
7-Apr-04	7:50:00	2.9	0.5926	2,222	101	-0.0138
7-Apr-04	7:53:37	2.7	0.6140	2,205	115	-0.0145
7-Apr-04	7:57:12	2.4	0.6573	2,172	121	-0.0132
7-Apr-04	8:00:42	2.0	0.6972	2,174	131	-0.0125
7-Apr-04	8:04:43	1.5	0.7862	2,191	126	-0.0092
7-Apr-04	8:08:32	1.4	0.7989	2,192	128	-0.0090
7-Apr-04	8:12:28	1.2	0.8672	2,182	118	-0.0068
7-Apr-04	8:16:15	1.1	0.8767	2,163	121	-0.0068
7-Apr-04	8:20:47	5.2	0.4202	2,237	62	-0.0176
7-Apr-04	8:25:36	6.3	0.3829	2,235	50	-0.0174
7-Apr-04	8:30:12	9.4	0.3086	2,278	32	-0.0171
7-Apr-04	8:34:54	11.6	0.2765	2,299	26	-0.0172
7-Apr-04	8:39:39	10.7	0.2869	2,294	33	-0.0204
7-Apr-04	8:44:23	6.7	0.3599	2,252	49	-0.0192
7-Apr-04	8:48:36	3.1	0.5108	2,215	83	-0.0155
7-Apr-04	8:52:43	1.5	0.7405	2,160	127	-0.0106
12-Apr-04	7:34:13	5.3	0.4696	2,140	78	-0.0174
12-Apr-04	7:38:13	3.8	0.5092	2,131	83	-0.0156
12-Apr-04	7:41:59	3.5	0.5440	2,128	94	-0.0154
12-Apr-04	7:45:31	2.9	0.5825	2,107	102	-0.0145
12-Apr-04	7:48:55	2.5	0.6186	2,118	113	-0.0140
12-Apr-04	7:52:19	2.1	0.6625	2,109	114	-0.0122
12-Apr-04	7:55:32	1.8	0.6951	2,117	122	-0.0117
12-Apr-04	7:58:40	1.5	0.7372	2,104	128	-0.0107
12-Apr-04	8:01:45	1.4	0.7742	2,108	130	-0.0097
12-Apr-04	8:04:49	1.2	0.8150	2,115	122	-0.0081
12-Apr-04	8:08:02	1.0	0.8519	2,113	120	-0.0072
12-Apr-04	8:11:13	1.0	0.8979	2,115	118	-0.0063
12-Apr-04	8:15:09	4.7	0.4316	2,147	63	-0.0168
12-Apr-04	8:19:11	5.6	0.3936	2,178	53	-0.0172
12-Apr-04	8:23:19	6.9	0.3535	2,178	40	-0.0163
12-Apr-04	8:27:41	8.3	0.3141	2,199	37	-0.0190
12-Apr-04	8:32:30	9.3	0.2966	2,195	27	-0.0157
12-Apr-04	8:37:14	9.7	0.2845	2,196	25	-0.0161
12-Apr-04	8:41:25	3.5	0.4694	2,131	74	-0.0167
12-Apr-04	8:46:17	9.6	0.2820	2,188	26	-0.0166
12-Apr-04	8:51:24	10.1	0.2708	2,207	21	-0.0147
13-Apr-04	7:31:12	4.7	0.4760	2,192	74	-0.0162
13-Apr-04	7:35:08	3.8	0.5169	2,184	84	-0.0155
13-Apr-04	7:38:46	3.1	0.5696	2,165	100	-0.0148
13-Apr-04	7:42:20	2.7	0.5920	2,166	104	-0.0143

Table C15 Pacer System 1 Static Source Error Corrections from the Tower Flyby Test Points (Concluded)

Flight Date	Time (local)	Indicated Angle of Attack (deg)	Instrument-Corrected Mach Number (n/d)	Instrument-Corrected Pressure Altitude (ft)	Static Source Error Corrections Altitude, ΔH_{pc} (ft)	Static Source Error Corrections Pressure, $\Delta P_{pc}/q_{cic}$ (n/d)
13-Apr-04	7:45:42	2.4	0.6409	2,146	115	-0.0132
13-Apr-04	7:48:54	2.1	0.6667	2,139	118	-0.0124
13-Apr-04	7:52:21	2.0	0.6919	2,146	126	-0.0122
13-Apr-04	7:55:35	1.7	0.7345	2,140	128	-0.0109
13-Apr-04	7:58:54	1.3	0.7769	2,145	129	-0.0096
13-Apr-04	8:02:26	1.2	0.8179	2,138	123	-0.0082
13-Apr-04	8:05:56	1.1	0.8621	2,151	116	-0.0068
13-Apr-04	8:09:25	1.0	0.9057	2,131	120	-0.0063
13-Apr-04	8:13:24	4.6	0.4312	2,195	62	-0.0168
13-Apr-04	8:17:30	5.6	0.3931	2,199	48	-0.0157
13-Apr-04	8:21:41	7.0	0.3519	2,223	46	-0.0187
13-Apr-04	8:26:18	8.8	0.3136	2,227	33	-0.0172
13-Apr-04	8:31:13	10.0	0.2855	2,232	27	-0.0172
13-Apr-04	8:36:04	9.2	0.2999	2,237	32	-0.0182
13-Apr-04	8:40:17	3.5	0.4686	2,191	78	-0.0175
13-Apr-04	8:44:14	2.9	0.5087	2,175	84	-0.0160
13-Apr-04	8:48:12	4.2	0.4317	2,193	64	-0.0170
13-Apr-04	8:53:07	10.7	0.2713	2,261	24	-0.0165
13-Apr-04	8:56:38	1.2	0.7069	2,136	130	-0.0120
30-Apr-04	7:22:18	4.5	0.4810	2,113	73	-0.0157
30-Apr-04	7:25:44	1.5	0.7761	2,095	123	-0.0092
30-Apr-04	7:30:04	9.6	0.3232	2,150	34	-0.0164
23-Nov-04	8:25:50	3.4	0.5442	2,164	86	-0.0141
23-Nov-04	8:29:38	1.6	0.7021	2,155	114	-0.0107
23-Nov-04	8:32:53	1.0	0.8527	2,160	116	-0.0070
23-Nov-04	8:36:33	4.3	0.4730	2,185	67	-0.0149
23-Nov-04	9:18:36	9.2	0.3105	2,245	39	-0.0206
23-Nov-04	9:23:23	10.7	0.2872	2,238	24	-0.0151
23-Nov-04	9:27:45	5.5	0.3933	2,211	57	-0.0184
23-Nov-04	9:31:39	1.9	0.6304	2,144	114	-0.0136
23-Nov-04	9:34:54	1.3	0.9078	2,127	117	-0.0061
23-Nov-04	9:38:19	2.5	0.5492	2,165	89	-0.0143
23-Nov-04	9:42:00	1.8	0.6201	2,140	110	-0.0135
23-Nov-04	9:45:35	1.3	0.7016	2,132	117	-0.0110
23-Nov-04	9:48:56	0.9	0.7719	2,134	125	-0.0095
23-Nov-04	9:52:08	0.8	0.8117	2,124	124	-0.0084

Notes:
1. System 1 used Dual Sonix digital pressure encoder serial number 8.
2. The static and total pressures from the Dual Sonix were corrected for instrument errors. Pressure altitude, airspeed, and Mach number were calculated using instrument-corrected static and total pressures.
3. The flaps and landing gear were retracted. ARDS pod on station 1, 370-gallon fuel tanks on stations 4 and 6.
4. F-16B USAF serial number 92-0457.
5. The static source error corrections were corrections to be added.
6. $\Delta P_{pc}/q_{cic}$ was equal to the ambient air pressure at the aircraft minus the instrument-corrected static pressure, all divided by the instrument-corrected compressible dynamic pressure

Table C16 F-16B Pacer System 1 Air Data from the C-17 Cross-Pace Test Points - March 2005

Time (ZULU)	Instrument-Corrected Pressure Altitude (ft)	Instrument-Corrected Airspeed (kts)	Instrument-Corrected Mach Number (n/d)	Angle of Attack (deg)	Geometric Altitude (ft MSL)
23:36:13	9,941	203.6	0.3688	8.0	10,503
23:34:11	9,928	248.0	0.4480	5.2	10,508
23:32:29	9,923	274.4	0.4950	4.2	10,511
23:27:26	9,924	331.4	0.5956	2.7	10,520
23:30:36	9,910	331.9	0.5962	2.7	10,513
23:25:45	9,918	346.1	0.6213	2.5	10,524
23:16:49	19,939	226.6	0.4967	6.6	20,774
23:14:33	19,928	274.3	0.5971	4.4	20,782
23:12:53	19,925	297.3	0.6447	3.6	20,786
23:10:39	19,940	322.2	0.6961	3.0	20,795
23:08:33	19,936	346.6	0.7458	2.5	20,782
22:59:23	29,907	221.8	0.5958	7.2	30,878
22:57:45	29,900	242.2	0.6472	6.0	30,889
22:55:46	29,908	262.1	0.6968	5.0	30,915
22:54:03	29,908	282.2	0.7461	4.2	30,918
22:50:30	29,910	302.6	0.7956	3.6	30,908
22:39:45	34,897	203.4	0.6109	9.2	35,846
22:38:00	34,899	216.1	0.6464	8.1	35,837
22:36:07	34,902	234.6	0.6977	6.8	35,841
22:32:02	34,914	252.6	0.7470	5.8	35,844
22:30:18	34,908	271.3	0.7968	4.8	35,843
22:22:19	39,899	208.2	0.6959	9.0	41,023
22:20:53	39,903	214.6	0.7157	8.4	41,039
22:19:03	39,910	224.7	0.7462	7.5	41,046

Notes:
1. F-16B USAF serial number 92-0457.
2. System 1 used Dual Sonix digital pressure encoder serial number 8.
3. The static and total pressures from the Dual Sonix were corrected for instrument errors. Pressure altitude, airspeed, and Mach number were calculated using instrument-corrected static and total pressures.
4. The F-16B pacer static and total pressures were corrected for formation errors. The corrected pressures were used to calculate pressure altitude, airspeed, and Mach number.
5. The flaps and landing gear were retracted. Advanced Range Data System (ARDS) pod on station 1, 370-gallon fuel tanks on stations 4 and 6.
6. The geometric altitude was based on differential GPS data recorded by the ARDS pod.
7. The angle of attack was measured by the production aircraft angle of attack system.
8. These test points were flown on 31 March 2005.

Table C17 F-16B Pacer System 2 Air Data from the C-17 Cross-Pace Test Points - March 2005

Time (ZULU)	Instrument-Corrected Pressure Altitude (ft)	Instrument-Corrected Airspeed (kts)	Instrument-Corrected Mach Number (n/d)	Angle of Attack (deg)	Geometric Altitude (ft MSL)
23:36:13	9,939	203.6	0.3688	8.0	10,503
23:34:11	9,926	248.0	0.4481	5.2	10,508
23:32:29	9,922	274.5	0.4951	4.2	10,511
23:27:26	9,922	331.4	0.5955	2.7	10,520
23:30:36	9,908	331.9	0.5963	2.7	10,513
23:25:45	9,917	346.2	0.6214	2.5	10,524
23:16:49	19,935	226.6	0.4967	6.6	20,774
23:14:33	19,924	274.3	0.5970	4.4	20,782
23:12:53	19,921	297.3	0.6446	3.6	20,786
23:10:39	19,936	322.2	0.6960	3.0	20,795
23:08:33	19,932	346.6	0.7458	2.5	20,782
22:59:23	29,900	221.7	0.5956	7.2	30,878
22:57:45	29,893	242.2	0.6471	6.0	30,889
22:55:46	29,900	262.0	0.6965	5.0	30,915
22:54:03	29,902	282.1	0.7459	4.2	30,918
22:50:30	29,904	302.7	0.7955	3.6	30,908
22:39:45	34,890	203.3	0.6106	9.2	35,846
22:38:00	34,892	216.0	0.6462	8.1	35,837
22:36:07	34,895	234.5	0.6974	6.8	35,841
22:32:02	34,907	252.6	0.7467	5.8	35,844
22:30:18	34,900	271.3	0.7966	4.8	35,843
22:22:19	39,889	208.1	0.6954	9.0	41,023
22:20:53	39,893	214.5	0.7152	8.4	41,039
22:19:03	39,901	224.6	0.7459	7.5	41,046

Notes: 1. F-16B USAF serial number 92-0457.
2. System 2 used Dual Sonix digital pressure encoder serial number 14.
3. The static and total pressures from the Dual Sonix were corrected for instrument errors. Pressure altitude, airspeed, and Mach number were calculated using instrument-corrected static and total pressures.
4. The F-16B pacer static and total pressures were corrected for formation errors. The corrected pressures were used to calculate pressure altitude, airspeed, and Mach number.
5. The flaps and landing gear were retracted. ARDS pod on station 1, 370 gallon fuel tanks on stations 4 and 6.
6. The geometric altitude was based on differential GPS data recorded by the ARDS pod.
7. The angle of attack was measured by the production aircraft angle of attack system.
8. These test points were flown on 31 March 2005.

Table C18 C-17 Air Data from the C-17 Cross-Pace Test Points - March 2005

Time (ZULU)	Trailing Cone Static Pressure (in Hg)	Kiel Probe Total Pressure (in Hg)	Pressure Altitude (ft)	Calibrated Airspeed (kts)	Geometric Altitude (ft MSL)
23:36:13	20.594	22.650	9,978	204.8	10,498
23:34:11	20.586	23.679	9,989	249.7	10,502
23:32:29	20.582	24.406	9,993	276.5	10,508
23:27:26	20.566	26.235	10,014	333.4	10,520
23:30:36	20.579	26.273	9,997	334.1	10,510
23:16:49	20.568	26.786	10,011	348.2	10,526
23:16:49	13.749	16.311	20,002	227.9	20,771
23:14:33	13.745	17.552	20,008	276.0	20,778
23:12:53	13.743	18.240	20,013	298.8	20,782
23:10:39	13.735	19.060	20,027	323.8	20,791
23:08:33	13.737	19.950	20,023	348.1	20,781
22:59:23	8.900	11.334	29,965	222.4	30,875
22:57:45	8.899	11.820	29,967	242.9	30,883
22:55:46	8.894	12.334	29,980	262.9	30,907
22:54:03	8.894	12.906	29,978	283.0	30,912
22:50:30	8.898	13.540	29,970	303.4	30,902
22:39:45	7.056	9.088	34,955	203.6	35,840
22:38:00	7.056	9.357	34,955	216.4	35,833
22:36:07	7.053	9.777	34,964	234.9	35,831
22:32:02	7.049	10.228	34,975	253.0	35,837
22:30:18	7.054	10.738	34,960	271.7	35,834
22:22:19	5.550	7.675	39,955	208.1	41,017
22:20:53	5.549	7.815	39,959	214.7	41,039
22:19:03	5.549	8.038	39,957	224.7	41,046

Notes:
1. C-17 USAF serial number 87-0025.
2. The geometric altitudes were measured by a G-Lite differential GPS system and were corrected to the location of the trailing cone pressure transducer.
3. The total and static pressures have been corrected for instrument errors.
4. These test points were flown on 31 March 2005.
5. The kiel probe total pressure was corrected to the location of the trailing cone pressure transducer.

Table C19 F-16B Pacer System 1 Static Source Error Corrections from the C-17 Cross-Pace Test Points - March 2005

Time (ZULU)	F-16B Pacer Pressure Altitude (ft)	F-16B Pacer Mach Number (n/d)	F-16B Pacer Angle of Attack (deg)	C-17 Calibrated Pressure Altitude (ft)	Static Source Error Corrections Altitude, ΔH_{pc} (ft)	Static Source Error Corrections Pressure, $\Delta P_{pc}/q_{cic}$ (n/d)	Aircraft Separation Distance (ft)
23:36:13	9,941	0.3688	8.0	9,978	37	-0.0147	224
23:34:11	9,928	0.4480	5.2	9,989	61	-0.0160	230
23:32:29	9,923	0.4950	4.2	9,993	70	-0.0149	180
23:27:26	9,924	0.5956	2.7	10,014	90	-0.0128	165
23:30:36	9,910	0.5962	2.7	9,997	88	-0.0125	156
23:16:49	9,918	0.6213	2.5	10,011	93	-0.0121	183
23:16:49	19,939	0.4967	6.6	20,002	63	-0.0145	202
23:14:33	19,928	0.5971	4.4	20,008	80	-0.0123	181
23:12:53	19,925	0.6447	3.6	20,013	88	-0.0114	169
23:10:39	19,940	0.6961	3.0	20,027	87	-0.0095	137
23:08:33	19,936	0.7458	2.5	20,023	87	-0.0081	173
22:59:23	29,907	0.5958	7.2	29,965	58	-0.0098	137
22:57:45	29,900	0.6472	6.0	29,967	67	-0.0093	158
22:55:46	29,908	0.6968	5.0	29,980	72	-0.0085	186
22:54:03	29,908	0.7461	4.2	29,978	70	-0.0071	219
22:50:30	29,910	0.7956	3.6	29,970	60	-0.0053	189
22:39:45	34,897	0.6109	9.2	34,955	58	-0.0096	242
22:38:00	34,899	0.6464	8.1	34,955	56	-0.0082	180
22:36:07	34,902	0.6977	6.8	34,964	62	-0.0076	199
22:32:02	34,914	0.7470	5.8	34,975	61	-0.0065	184
22:30:18	34,908	0.7968	4.8	34,960	52	-0.0048	199
22:22:19	39,899	0.6959	9.0	39,955	56	-0.0070	180
22:20:53	39,903	0.7157	8.4	39,959	56	-0.0066	190
22:19:03	39,910	0.7462	7.5	39,957	47	-0.0050	178

Notes:
1. F-16B USAF serial number 92-0457 and C-17 USAF serial number 87-0025.
2. System 1 used Dual Sonix digital pressure encoder serial number 8.
3. The static and total pressures from the Dual Sonix were corrected for instrument errors. Pressure altitude, airspeed, and Mach number were calculated using instrument-corrected static and total pressures.
4. The F-16B pacer static and total pressures were corrected for formation errors. The corrected pressures were used to calculate pressure altitude, airspeed, and Mach number.
5. The flaps and landing gear were retracted. ARDS pod on station 1, 370 gallon fuel tanks on stations 4 and 6.
6. The angle of attack was measured by the production aircraft angle of attack system.
7. These test points were flown on 31 March 2005.
8. The static source error corrections were corrections to be added.
9. The airspeed and Mach number static source error corrections were calculated from the altitude static error corrections
10. Aircraft separation distance was the distance between the wingtips of the two aircraft in formation.
11. $\Delta P_{pc}/q_{cic}$ was equal to the ambient air pressure at the aircraft minus the instrument-corrected static pressure, all divided by the instrument-corrected compressible dynamic pressure.

Table C20 F-16B Pacer System 2 Static Source Error Corrections from the C-17 Cross-Pace Test Points - March 2005

Time (ZULU)	F-16B Pacer Pressure Altitude (ft)	F-16B Pacer Mach Number (n/d)	F-16B Pacer Angle of Attack (deg)	C-17 Calibrated Pressure Altitude (ft)	Static Source Error Corrections Altitude, ΔH_{pc} (ft)	Static Source Error Corrections Pressure, $\Delta P_{pc}/q_{cic}$ (n/d)	Aircraft Separation Distance (ft)
23:36:13	9,939	0.3688	8.0	9,978	39	-0.0154	224
23:34:11	9,926	0.4481	5.2	9,989	63	-0.0165	230
23:32:29	9,922	0.4951	4.2	9,993	71	-0.0151	180
23:27:26	9,922	0.5955	2.7	10,014	92	-0.0131	165
23:30:36	9,908	0.5963	2.7	9,997	89	-0.0127	156
23:16:49	9,917	0.6214	2.5	10,011	94	-0.0122	183
23:16:49	19,935	0.4967	6.6	20,002	67	-0.0153	202
23:14:33	19,924	0.5970	4.4	20,008	84	-0.0129	181
23:12:53	19,921	0.6446	3.6	20,013	92	-0.0119	169
23:10:39	19,936	0.6960	3.0	20,027	91	-0.0099	137
23:08:33	19,932	0.7458	2.5	20,023	91	-0.0085	173
22:59:23	29,900	0.5956	7.2	29,965	65	-0.0109	137
22:57:45	29,893	0.6471	6.0	29,967	74	-0.0103	158
22:55:46	29,900	0.6965	5.0	29,980	79	-0.0094	186
22:54:03	29,902	0.7459	4.2	29,978	77	-0.0078	219
22:50:30	29,904	0.7955	3.6	29,970	66	-0.0058	189
22:39:45	34,890	0.6106	9.2	34,955	65	-0.0108	242
22:38:00	34,892	0.6462	8.1	34,955	63	-0.0092	180
22:36:07	34,895	0.6974	6.8	34,964	69	-0.0086	199
22:32:02	34,907	0.7467	5.8	34,975	68	-0.0072	184
22:30:18	34,900	0.7966	4.8	34,960	59	-0.0054	199
22:22:19	39,889	0.6954	9.0	39,955	66	-0.0083	180
22:20:53	39,893	0.7152	8.4	39,959	66	-0.0078	190
22:19:03	39,901	0.7459	7.5	39,957	56	-0.0061	178

Notes:
1. F-16B USAF serial number 92-0457 and C-17 USAF serial number 87-0025.
2. System 2 used Dual Sonix digital pressure encoder serial number 14.
3. The static and total pressures from the Dual Sonix were corrected for instrument errors. Pressure altitude, airspeed, and Mach number were calculated using instrument-corrected static and total pressures.
4. The F-16B pacer static and total pressures were corrected for formation errors. The corrected pressures were used to calculate pressure altitude, airspeed, and Mach number.
5. The flaps and landing gear were retracted. Advanced Range Data System pod on station 1, 370 gallon fuel tanks on stations 4 and 6.
6. The angle of attack was measured by the production aircraft angle of attack system.
7. These test points were flown on 31 March 2005.
8. The static source error corrections were corrections to be added.
9. The airspeed and Mach number static source error corrections were calculated from the altitude static error corrections.
10. Aircraft separation distance was the distance between the wingtips of the two aircraft in formation.
11. $\Delta P_{pc}/q_{cic}$ was equal to the ambient air pressure at the aircraft minus the instrument-corrected static pressure, all divided by the instrument-corrected compressible dynamic pressure.

Table C21 F-16B Pacer System 1 Total Pressure Error Corrections from the C-17 Cross-Pace Test Points - March 2005

	F-16B Pacer							
	Instrument-Corrected							
Time (ZULU)	Pressure Altitude (ft)	Mach Number (n/d)	Indicated Angle of Attack (deg)	Inst-Corr Total Pressure (in Hg)	C-17 Kiel Total Pressure (in Hg)	Total Pressure Error Correction (in Hg)	F-16B Pacer Instrument-Corrected Compressible Dynamic Pressure (in Hg)	Total Source Error Correction Coefficient, $\Delta P_t/q_{cic}$ (n/d)
23:36:13	9,941	0.3688	8.0	22.656	22.650	-0.006	2.031	-0.0028
23:34:11	9,928	0.4480	5.2	23.683	23.679	-0.004	3.048	-0.0014
23:32:29	9,923	0.4950	4.2	24.401	24.406	0.005	3.762	0.0014
23:27:26	9,924	0.5956	2.7	26.233	26.235	0.002	5.596	0.0003
23:30:36	9,910	0.5962	2.7	26.261	26.273	0.012	5.612	0.0021
23:16:49	9,918	0.6213	2.5	26.781	26.786	0.006	6.138	0.0010
23:16:49	19,939	0.4967	6.6	16.316	16.311	-0.005	2.531	-0.0022
23:14:33	19,928	0.5971	4.4	17.552	17.552	0.000	3.760	0.0001
23:12:53	19,925	0.6447	3.6	18.242	18.240	-0.002	4.448	-0.0004
23:10:39	19,940	0.6961	3.0	19.055	19.060	0.006	5.270	0.0011
23:08:33	19,936	0.7458	2.5	19.945	19.950	0.006	6.158	0.0009
22:59:23	29,907	0.5958	7.2	11.344	11.334	-0.010	2.421	-0.0043
22:57:45	29,900	0.6472	6.0	11.829	11.820	-0.009	2.903	-0.0033
22:55:46	29,908	0.6968	5.0	12.342	12.334	-0.008	3.419	-0.0024
22:54:03	29,908	0.7461	4.2	12.911	12.906	-0.004	3.988	-0.0011
22:50:30	29,910	0.7956	3.6	13.541	13.540	-0.001	4.619	-0.0002
22:39:45	34,897	0.6109	9.2	9.102	9.088	-0.014	2.027	-0.0068
22:38:00	34,899	0.6464	8.1	9.369	9.357	-0.012	2.295	-0.0052
22:36:07	34,902	0.6977	6.8	9.792	9.777	-0.014	2.718	-0.0053
22:32:02	34,914	0.7470	5.8	10.238	10.228	-0.010	3.168	-0.0032
22:30:18	34,908	0.7968	4.8	10.746	10.738	-0.007	3.674	-0.0020
22:22:19	39,899	0.6959	9.0	7.691	7.675	-0.016	2.126	-0.0077

Table C21 F-16B Pacer System 1 Total Pressure Error Corrections from the C-17 Cross-Pace Test Points - March 2005 (Concluded)

	F-16B Pacer							
	Instrument-Corrected							
Time (ZULU)	Pressure Altitude (ft)	Mach Number (n/d)	Indicated Angle of Attack (deg)	Inst-Corr Total Pressure (in Hg)	C-17 Kiel Total Pressure (in Hg)	Total Pressure Error Correction (in Hg)	F-16B Pacer Instrument-Corrected Compressible Dynamic Pressure (in Hg)	Total Source Error Correction Coefficient, $\Delta P_t/q_{cic}$ (n/d)
22:20:53	39,903	0.7157	8.4	7.828	7.815	-0.013	2.264	-0.0059
22:19:03	39,910	0.7462	7.5	8.049	8.038	-0.011	2.487	-0.0046

Notes: 1. F-16B USAF serial number 92-0457 and C-17 USAF serial number 87-0025.
2. System 1 used Dual Sonix digital pressure encoder serial number 8.
3. The static and total pressures from the Dual Sonix were corrected for instrument errors. Pressure altitude, airspeed, and Mach number were calculated using instrument-corrected static and total pressures.
4. The F-16B pacer static and total pressures were corrected for formation errors. The corrected pressures were used to calculate pressure altitude, airspeed, Mach number, and compressible dynamic pressure.
5. Flaps and landing gear were retracted. Advanced range data system pod on station 1, 370 gallon fuel tanks on stations 4 and 6.
6. The angle of attack was measured by the production aircraft angle of attack system.
7. These test points were flown on 31 March 2005.
8. All corrections were corrections to be added.

Table C22 F-16B Pacer System 2 Total Pressure Error Corrections from the C-17 Cross-Pace Test Points - March 2005

Time (ZULU)	F-16B Pacer Instrument-Corrected Pressure Altitude (ft)	F-16B Pacer Instrument-Corrected Mach Number (n/d)	F-16B Pacer Indicated Angle of Attack (deg)	F-16B Pacer Inst-Corr Total Pressure (in Hg)	C-17 Kiel Total Pressure (in Hg)	Total Pressure Error Correction (in Hg)	F-16B Pacer Instrument-Corrected Compressible Dynamic Pressure (in Hg)	Total Source Error Correction Coefficient, $\Delta P_t/q_{cic}$(n/d)
23:36:13	9,939	0.3688	8.0	22.658	22.650	-0.008	2.032	-0.0038
23:34:11	9,926	0.4481	5.2	23.685	23.679	-0.006	3.049	-0.0021
23:32:29	9,922	0.4951	4.2	24.403	24.406	0.004	3.764	0.0009
23:27:26	9,922	0.5955	2.7	26.235	26.235	0.001	5.595	0.0001
23:30:36	9,908	0.5963	2.7	26.264	26.273	0.009	5.613	0.0016
23:16:49	9,917	0.6214	2.5	26.783	26.786	0.004	6.140	0.0006
23:16:49	19,935	0.4967	6.6	16.319	16.311	-0.008	2.532	-0.0033
23:14:33	19,924	0.5970	4.4	17.553	17.552	-0.002	3.760	-0.0004
23:12:53	19,921	0.6446	3.6	18.243	18.240	-0.003	4.448	-0.0008
23:10:39	19,936	0.6960	3.0	19.057	19.060	0.004	5.270	0.0007
23:08:33	19,932	0.7458	2.5	19.946	19.950	0.004	6.157	0.0006
22:59:23	29,900	0.5956	7.2	11.346	11.334	-0.012	2.420	-0.0051
22:57:45	29,893	0.6471	6.0	11.831	11.820	-0.012	2.902	-0.0040
22:55:46	29,900	0.6965	5.0	12.343	12.334	-0.009	3.417	-0.0027
22:54:03	29,902	0.7459	4.2	12.913	12.906	-0.006	3.987	-0.0015
22:50:30	29,904	0.7955	3.6	13.543	13.540	-0.003	4.619	-0.0007
22:39:45	34,890	0.6106	9.2	9.103	9.088	-0.015	2.026	-0.0075
22:38:00	34,892	0.6462	8.1	9.371	9.357	-0.013	2.294	-0.0058
22:36:07	34,895	0.6974	6.8	9.792	9.777	-0.015	2.716	-0.0055
22:32:02	34,907	0.7467	5.8	10.239	10.228	-0.011	3.167	-0.0035
22:30:18	34,900	0.7966	4.8	10.748	10.738	-0.010	3.674	-0.0026
22:22:19	39,889	0.6954	9.0	7.691	7.675	-0.016	2.124	-0.0077

Table C22 F-16B Pacer System 2 Total Pressure Error Corrections from the C-17 Cross-Pace Test Points - March 2005 (Concluded)

Time (ZULU)	F-16B Pacer				C-17 Kiel Total Pressure (in Hg)	Total Pressure Error Correction (in Hg)	F-16B Pacer Instrument-Corrected Compressible Dynamic Pressure (in Hg)	Total Source Error Correction Coefficient, $\Delta P_t/q_{cic}$(n/d)
	Instrument-Corrected		Indicated Angle of Attack (deg)	Inst-Corr Total Pressure (in Hg)				
	Pressure Altitude (ft)	Mach Number (n/d)						
22:20:53	39,893	0.7152	8.4	7.828	7.815	-0.013	2.261	-0.0059
22:19:03	39,901	0.7459	7.5	8.050	8.038	-0.013	2.486	-0.0050

Notes:
1. F-16B USAF serial number 92-0457 and C-17 USAF serial number 87-0025.
2. System 2 used Dual Sonix digital pressure encoder serial number 14.
3. The static and total pressures from the Dual Sonix were corrected for instrument errors. Pressure altitude, airspeed, and Mach number were calculated using instrument-corrected static and total pressures.
4. The F-16B pacer static and total pressures were corrected for formation errors. The corrected pressures were used to calculate pressure altitude, airspeed, Mach number, and compressible dynamic pressure.
5. The flaps and landing gear were retracted. Advanced range data system pod on station 1, 370 gallon fuel tanks on stations 4 and 6.
6. The angle of attack was measured by the production aircraft angle of attack system.
7. These test points were flown on 31 March 2005.
8. All corrections were corrections to be added.

Table C23 F-16B Pacer System 1 Air Data from the C-17 Cross-Pace Test Points - December 2004

Flight Date	Time (ZULU)	Instrument-Corrected Pressure Altitude (ft)	Instrument-Corrected Airspeed (kt)	Instrument-Corrected Mach Number (n/d)	Angle of Attack (deg)	Geometric Altitude (ft MSL)
10-Dec-04	19:22:00	35,684	259.2	0.7745	5.4	37,567
10-Dec-04	19:28:18	34,068	282.2	0.8091	4.4	35,891
10-Dec-04	19:30:58	34,081	276.4	0.7939	4.6	35,913
10-Dec-04	19:34:39	34,080	268.4	0.7737	4.9	35,876
10-Dec-04	19:40:30	34,083	260.2	0.7528	5.3	35,858
10-Dec-04	19:43:56	34,075	253.7	0.7357	5.5	35,857
10-Dec-04	19:44:30	34,075	253.4	0.7348	5.6	35,864
10-Dec-04	19:48:25	34,068	245.5	0.7129	5.9	35,890
10-Dec-04	19:49:07	34,070	245.0	0.7107	5.9	35,925
10-Dec-04	19:53:43	34,066	237.9	0.6915	6.2	35,919
10-Dec-04	20:02:05	34,060	231.6	0.6743	6.5	35,893
21-Dec-04	19:56:01	32,894	291.4	0.8147	4.4	33,484
21-Dec-04	20:12:45	32,888	291.1	0.8134	4.3	33,513
21-Dec-04	20:25:32	32,869	287.0	0.8036	4.5	33,425

Notes:
1. F-16B USAF serial number 92-0457.
2. System 1 used Dual Sonix digital pressure encoder serial number 8.
3. The static and total pressures from the Dual Sonix were corrected for instrument errors. Pressure altitude, airspeed, and Mach number were calculated using instrument-corrected static and total pressures.
4. The pressure altitudes were corrected for formation errors. The static pressures corresponding to the corrected pressure altitudes were used to calculate the airspeeds and Mach numbers.
5. The flaps and landing gear were retracted. Advanced Range Data System (ARDS) pod on station 1, 370 gallon fuel tanks on stations 4 and 6.
6. The geometric altitude was based on differential GPS data recorded by the ARDS pod.
7. The angle of attack was measured by the production aircraft angle of attack system.
8. n/d - nondimensional

Table C24 C-17 Air Data from the C-17 Cross-Pace Test Points - December 2004

Flight Date	Time (ZULU)	Trailing Cone Static Pressure (in Hg)	Kiel Probe Total Pressure (in Hg)	Pressure Altitude (ft)	Calibrated Airspeed (kts)	Geometric Altitude	
						GPS 1 (ft MSL)	GPS 4 (ft MSL)
10-Dec-04	19:22:00	6.788	10.135	35,765	259.4	37,506	37,502
10-Dec-04	19:28:18	7.332	11.347	34,144	283.1	35,824	35,817
10-Dec-04	19:30:58	7.327	11.169	34,159	277.2	35,836	35,827
10-Dec-04	19:34:39	7.325	10.934	34,165	269.0	35,824	35,821
10-Dec-04	19:40:30	7.327	10.720	34,159	261.1	35,832	35,820
10-Dec-04	19:43:56	7.327	10.535	34,160	254.2	35,837	35,830
10-Dec-04	19:44:30	7.326	10.532	34,161	254.1	35,841	35,840
10-Dec-04	19:48:25	7.326	10.323	34,161	246.0	35,852	35,847
10-Dec-04	19:49:07	7.326	10.323	34,162	245.9	35,854	35,857
10-Dec-04	19:53:43	7.327	10.143	34,160	238.6	35,855	35,856
10-Dec-04	20:02:05	7.329	9.977	34,152	231.6	35,829	35,832
21-Dec-04	19:56:01	7.750	12.032	32,964	291.9	33,455	33,458
21-Dec-04	20:12:45	7.749	12.015	32,967	291.4	33,471	33,462
21-Dec-04	20:25:32	7.753	11.933	32,956	288.6	33,415	33,404

Notes: 1. C-17 USAF serial number 87-0025.
2. The geometric altitudes were measured by the production GPS systems and were corrected to the location of the trailing cone pressure transducer.
3. The total and static pressures have been corrected for instrument errors.

Table C25 F-16B Pacer System 1 Static Source Error
Corrections from the C-17 Cross-Pace Test Points - December 2004

Flight Date	Time (ZULU)	F-16B Pacer Pressure Altitude (ft)	F-16B Pacer Mach Number (n/d)	F-16B Pacer Angle of Attack (deg)	C-17 Calibrated Pressure Altitude (ft)	Static Source Error Corrections Altitude, ΔH_{pc} (ft)	Static Source Error Corrections Pressure, $\Delta P_{pc}/q_{cic}$ (n/d)
10-Dec-04	19:22:00	35,684	0.7745	5.4	35,765	80	-0.0079
10-Dec-04	19:28:18	34,068	0.8091	4.4	34,144	75	-0.0066
10-Dec-04	19:30:58	34,081	0.7939	4.6	34,159	78	-0.0072
10-Dec-04	19:34:39	34,080	0.7737	4.9	34,165	85	-0.0082
10-Dec-04	19:40:30	34,083	0.7528	5.3	34,159	77	-0.0079
10-Dec-04	19:43:56	34,075	0.7357	5.5	34,160	84	-0.0092
10-Dec-04	19:44:30	34,075	0.7348	5.6	34,161	87	-0.0095
10-Dec-04	19:48:25	34,068	0.7129	5.9	34,161	94	-0.0109
10-Dec-04	19:49:07	34,070	0.7107	5.9	34,162	92	-0.0108
10-Dec-04	19:53:43	34,066	0.6915	6.2	34,160	94	-0.0117
10-Dec-04	20:02:05	34,060	0.6743	6.5	34,152	92	-0.0122
21-Dec-04	19:56:01	32,894	0.8147	4.4	32,964	70	-0.0060
21-Dec-04	20:12:45	32,888	0.8134	4.3	32,967	79	-0.0068
21-Dec-04	20:25:32	32,869	0.8036	4.5	32,956	86	-0.0076

Notes:
1. F-16B USAF serial number 92-0457 and C-17 USAF serial number 87-0025.
2. System 1 used Dual Sonix digital pressure encoder serial number 8.
3. The static and total pressures from the Dual Sonix were corrected for instrument errors. Pressure altitude,
airspeed, and Mach number were calculated using instrument-corrected static and total pressures.
4. The F-16B pacer pressure altitudes were corrected for formation errors. The static pressures corresponding to the corrected pressure altitudes were used to calculate the airspeeds and Mach numbers.
5. The flaps and landing gear were retracted. Advanced range data system pod on station 1, 370 gallon fuel tanks on stations 4 and 6.
6. The angle of attack was measured by the production aircraft angle of attack system.
7. The static source error corrections were corrections to be added.
8. The airspeed and Mach number static source error corrections were calculated from the altitude static error corrections.
9. n/d - nondimensional

Table C26 F-16B Pacer System 1 Air Data from the T-38C Cross-Pace Test Points

Time (local)	Instrument-Corrected Pressure Altitude (ft)	Instrument-Corrected Airspeed (kt)	Instrument-Corrected Mach Number (n/d)	Indicated Angle of Attack (deg)	Geometric Altitude (ft MSL)
8:46:13	29,904	366.2	0.9444	2.5	30,523
8:47:12	29,953	361.8	0.9350	2.3	30,552
8:48:28	29,965	355.6	0.9210	2.4	30,547
8:49:24	29,970	356.4	0.9230	2.4	30,539
8:51:47	29,861	351.9	0.9107	2.4	30,438
8:52:44	29,869	344.0	0.8925	2.4	30,457
8:53:55	29,886	322.9	0.8434	2.9	30,497
8:55:11	29,910	302.4	0.7949	3.7	30,552
8:56:29	29,929	281.3	0.7444	4.4	30,596
8:59:18	29,943	260.1	0.6924	5.1	30,602
9:00:39	29,966	241.2	0.6457	6.1	30,605
9:03:18	29,965	219.8	0.5915	7.6	30,571
8:57:03	29,911	281.6	0.7448	4.4	30,583
9:01:56	29,972	242.9	0.6499	6.0	30,602
9:05:10	29,955	244.1	0.6528	6.0	30,554
9:06:28	29,941	264.2	0.7024	5.0	30,530
9:08:20	29,915	282.3	0.7465	4.2	30,512
9:09:25	29,946	302.8	0.7966	3.5	30,545
9:10:22	29,885	322.9	0.8435	3.0	30,487
9:11:11	29,878	343.2	0.8909	2.4	30,484
9:11:58	29,840	353.0	0.9129	2.2	30,453

Notes:
1. F-16B USAF serial number 92-0457.
2. System 1 used Dual Sonix digital pressure encoder serial number 8.
3. The static and total pressures from the Dual Sonix were corrected for instrument errors. Pressure altitude, airspeed, and Mach number were calculated using instrument-corrected static and total pressures.
4. The flaps and landing gear were retracted. Advanced range data system pod on station 1, 370 gallon fuel tanks on stations 4 and 6.
5. The geometric altitude was based on differential GPS data recorded by the ARDS pod.
6. The angle of attack was measured by the production aircraft angle of attack system.
7. These test points were flown on 23 November 2004.

Table C27 T-38C Air Data from the T-38C Cross-Pace Test Points

Time (local)	Calibrated Pressure Altitude (ft)	Calibrated Airspeed (kt)	Calibrated Mach Number (n/d)	Geometric Altitude (ft MSL)
8:46:13	29,986	366.9	0.9475	30,512
8:47:12	30,031	362.9	0.9390	30,544
8:48:28	30,040	356.6	0.9248	30,528
8:49:24	30,044	357.6	0.9271	30,524
8:51:47	29,933	353.1	0.9147	30,424
8:52:44	29,936	344.7	0.8954	30,444
8:53:55	29,950	323.8	0.8466	30,480
8:55:11	29,976	303.3	0.7982	30,536
8:56:29	30,001	282.8	0.7490	30,580
8:59:18	30,015	261.2	0.6963	30,584
9:00:39	30,032	241.8	0.6480	30,588
9:03:18	30,026	220.9	0.5951	30,552
8:57:03	29,983	282.6	0.7482	30,568
9:01:56	30,043	243.6	0.6528	30,584
9:05:10	30,027	245.3	0.6568	30,540
9:06:28	30,020	265.6	0.7071	30,524
9:08:20	29,990	283.5	0.7505	30,504
9:09:25	30,013	303.7	0.7998	30,536
9:10:22	29,954	324.0	0.8472	30,476
9:11:11	29,955	344.8	0.8958	30,476
9:11:58	29,922	354.2	0.9170	30,444

Notes: 1. T-38C USAF serial number 64-13302.
2. Geometric altitude was measured by the production aircraft embedded GPS/INS.
3. These test points were flown on 23 November 2004.
4. n/d - nondimensional.

Table C28 F-16B Pacer System 1 Static Source Error Corrections from the T-38C Cross-Pace Test Points

Time (local)	F-16B Pacer Inst-Corr Pressure Altitude (ft)	F-16B Pacer Inst-Corr Mach Number (n/d)	F-16B Pacer Indicated Angle of Attack (deg)	T-38C Calibrated Pressure Altitude (ft)	Static Source Error Corrections Altitude, ΔH_{pc} (ft)	Static Source Error Corrections Pressure, $\Delta P_{pc}/q_{cic}$ (ft)
8:46:13	29,904	0.9444	2.5	29,986	82	-0.0048
8:47:12	29,953	0.9350	2.3	30,031	78	-0.0047
8:48:28	29,965	0.9210	2.4	30,040	75	-0.0047
8:49:24	29,970	0.9230	2.4	30,044	74	-0.0046
8:51:47	29,861	0.9107	2.4	29,933	72	-0.0046
8:52:44	29,869	0.8925	2.4	29,936	67	-0.0045
8:53:55	29,886	0.8434	2.9	29,950	64	-0.0049
8:55:11	29,910	0.7949	3.7	29,976	66	-0.0058
8:56:29	29,929	0.7444	4.4	30,001	72	-0.0074
8:59:18	29,943	0.6924	5.1	30,015	72	-0.0087
9:00:39	29,966	0.6457	6.1	30,032	66	-0.0092
9:03:18	29,965	0.5915	7.6	30,026	61	-0.0104
8:57:03	29,911	0.7448	4.4	29,983	72	-0.0073
9:01:56	29,972	0.6499	6.0	30,043	71	-0.0098
9:05:10	29,955	0.6528	6.0	30,027	72	-0.0099
9:06:28	29,941	0.7024	5.0	30,020	79	-0.0092
9:08:20	29,915	0.7465	4.2	29,990	75	-0.0076
9:09:25	29,946	0.7966	3.5	30,013	67	-0.0059
9:10:22	29,885	0.8435	3.0	29,954	69	-0.0053
9:11:11	29,878	0.8909	2.4	29,955	77	-0.0052
9:11:58	29,840	0.9129	2.2	29,922	82	-0.0052

Notes:
1. F-16B USAF serial number 92-0457 and T-38C USAF serial number 64-13302.
2. System 1 used Dual Sonix digital pressure encoder serial number 8.
3. The static and total pressures from the Dual Sonix were corrected for instrument errors. Pressure altitude, airspeed, and Mach number were calculated using instrument-corrected static and total pressures.
4. The flaps and landing gear were retracted. Advanced range data system pod on station 1, 370 gallon fuel tanks on stations 4 and 6.
5. The angle of attack was measured by the production aircraft angle of attack system.
6. These test points were flown on 23 November 2004.
7. The static source error corrections were corrections to be added.
8. n/d - nondimensional.

Table C29 F-16B Pacer System 1 Total Pressure Error Corrections from the T-38C Cross-Pace Test Points

	F-16B Pacer							
	Instrument-Corrected		Indicated	Inst-Corr	T-38C	Total Pressure	F-16B Pacer	Total Source Error
Time (ZULU)	Pressure Altitude (ft)	Mach Number (n/d)	Angle of Attack (deg)	Total Pressure (in Hg)	Total Pressure (in Hg)	Error Correction (in Hg)	Instrument-Corrected Compressible Dynamic Pressure (in Hg)	Correction Coefficient, $\Delta P_t/q_{cic}$ (n/d)
8:46:13	29,904	0.9444	2.5	15.852	15.846	-0.006	6.928	-0.0009
8:47:12	29,953	0.9350	2.3	15.652	15.666	0.014	6.747	0.0021
8:48:28	29,965	0.9210	2.4	15.401	15.411	0.011	6.501	0.0017
8:49:24	29,970	0.9230	2.4	15.432	15.449	0.018	6.534	0.0027
8:51:47	29,861	0.9107	2.4	15.301	15.318	0.017	6.359	0.0027
8:52:44	29,869	0.8925	2.4	14.996	14.996	-0.001	6.058	-0.0001
8:53:55	29,886	0.8434	2.9	14.227	14.232	0.005	5.296	0.0010
8:55:11	29,910	0.7949	3.7	13.532	13.535	0.003	4.610	0.0007
8:56:29	29,929	0.7444	4.4	12.877	12.891	0.014	3.963	0.0036
8:59:18	29,943	0.6924	5.1	12.273	12.274	0.001	3.365	0.0003
9:00:39	29,966	0.6457	6.1	11.778	11.766	-0.013	2.879	-0.0044
9:03:18	29,965	0.5915	7.6	11.277	11.277	-0.001	2.377	-0.0002
8:57:03	29,911	0.7448	4.4	12.893	12.893	-0.001	3.972	-0.0001
9:01:56	29,972	0.6499	6.0	11.817	11.806	-0.010	2.920	-0.0036
9:05:10	29,955	0.6528	6.0	11.855	11.855	0.000	2.951	0.0001
9:06:28	29,941	0.7024	5.0	12.385	12.392	0.008	3.476	0.0022
9:08:20	29,915	0.7465	4.2	12.911	12.917	0.006	3.991	0.0014
9:09:25	29,946	0.7966	3.5	13.532	13.533	0.001	4.625	0.0001
9:10:22	29,885	0.8435	3.0	14.229	14.238	0.009	5.297	0.0017
9:11:11	29,878	0.8909	2.4	14.964	14.992	0.028	6.029	0.0046
9:11:58	29,840	0.9129	2.2	15.352	15.365	0.013	6.402	0.0021

Notes: 1. F-16B USAF serial number 92-0457 and T-38C USAF serial number 64-13302.
2. System 1 used Dual Sonix digital pressure encoder serial number 8.
3. The static and total pressures from the Dual Sonix were corrected for instrument errors. Pressure altitude, airspeed, and Mach number were calculated using instrument-corrected static and total pressures.
4. The flaps and landing gear were retracted. Advanced range data system pod on station 1, 370 gallon fuel tanks on stations 4 and 6.
5. The angle of attack was measured by the production aircraft angle of attack system.
6. These test points were flown on 23 November 2004.
7. All corrections were corrections to be added.

Table C30 Pacer System 1 Static Source Error Corrections Determined from the GPS Cloverleaf Method

Pressure Altitude (ft)	Mach Number (n/d)	Total Air Temperature (K)	ARDS North Inertial Velocity (kts)	ARDS East Inertial Velocity (kts)	Average Mach Number (n/d)	Average Indicated Angle of Attack (deg)	Static Source Error Corrections: Pressure, $\Delta P_{pc}/q_{cic}$ (n/d)	Static Source Error Corrections: Pressure Altitude (ft)
35,002	0.7987	241.6	240.6	-295.4				
35,001	0.7984	241.3	-524.3	-75.2	0.7987	3.7	-0.0142	156
35,003	0.7988	241.4	45.8	476.7				
34,997	0.8483	244.7	263.5	-315.5				
34,996	0.8485	244.7	-548.9	-90.2	0.8485	3.2	-0.0090	114
34,998	0.8487	244.8	55.9	498.1				
34,990	0.8984	248.0	279.9	-335.8				
34,992	0.8983	247.9	-576.1	-98.5	0.8982	2.7	-0.0086	124
34,995	0.8979	247.9	59.2	527.5				
39,897	0.7030	234.5	239.8	-244.1				
39,899	0.7022	234.0	-431.4	-58.9	0.7035	7.4	-0.0051	42
39,899	0.7022	234.0	67.2	426.9				
39,901	0.8014	240.5	276.8	-285.5				
39,903	0.8057	240.8	-491.3	-74.5	0.8059	5.5	-0.0068	75
39,904	0.8071	240.5	84.9	483.1				
39,901	0.8014	240.5	276.8	-285.5				
39,903	0.8057	240.8	-491.3	-74.5	0.8050	5.5	-0.0067	74
39,904	0.8045	240.5	86.6	481.2				
39,901	0.8473	242.7	290.7	-306.4				
39,902	0.8465	243.4	-514.8	-81.7	0.8474	4.9	-0.0047	59
39,903	0.8446	243.0	88.0	501.7				

Table C30 Pacer System 1 Static Source Error Corrections Determined from the GPS Cloverleaf Method (Concluded)

Pressure Altitude (ft)	Mach Number (n/d)	Total Air Temperature (K)	ARDS North Inertial Velocity (kts)	ARDS East Inertial Velocity (kts)	Average Mach Number (n/d)	Average Indicated Angle of Attack (deg)	Static Source Error Corrections: Pressure, $\Delta P_{pc}/q_{cic}$ (n/d)	Static Source Error Corrections: Pressure Altitude (ft)
39,888	0.8981	245.2	301.0	-332.3	0.8987	4.2	-0.0058	83
39,889	0.8988	245.8	-547.4	-87.3				
39,890	0.8953	245.8	90.9	528.3				

Notes: 1. F-16B USAF serial number 92-0457.

2. System 1 used Dual Sonix digital pressure encoder serial number 8.

3. The static and total pressures from the Dual Sonix were corrected for instrument errors. Pressure altitude, airspeed, and Mach number were calculated using instrument-corrected static and total pressures.

4. The flaps and landing gear were retracted. Advanced range data system (ARDS) pod on station 1, 370 gallon fuel tanks on stations 4 and 6.

5. The angle of attack was measured by the production aircraft angle of attack system.

6. These test points were flown on 23 November 2004.

7. All corrections were corrections to be added.

8. A total temperature probe recovery factor of 1.0 was assumed in the data analysis.

9. The total temperatures measured by the flight test probe were used in the data analysis.

10. The inertial velocities were measured by the ARDS pod mounted on station 1.

11. $\Delta P_{pc}/q_{cic}$ - Static source error correction coefficient to be added to instrument-corrected static pressure

12. ARDS - Advanced Range Data System

13. n/d - nondimensional.

Table C31 Wind Speeds and Directions from the GPS Cloverleaf Method

Pressure Altitude (1,000 ft)	Mach Number (n/d)	Wind Speed: Aircrew Notes (kt)	Wind Speed: Cloverleaf (kt)	Wind Speed: UFTAS (kt)	Wind Speed: Difference (kt)	Wind Direction: Aircrew Notes (deg)	Wind Direction: Cloverleaf (deg)	Wind Direction: UFTAS (deg)	Wind Direction: Difference (deg)
35	0.80	84	86	85	1	324	336	338	-2
35	0.80	88	86	89	-3	321	336	336	1
35	0.80	87	86	85	1	322	336	335	1
35	0.85	84	84	84	-1	326	339	341	-2
35	0.85	84	84	86	-2	325	339	338	1
35	0.85	83	84	82	2	326	339	338	1
35	0.90	87	85	86	-1	325	338	340	-3
35	0.90	86	85	88	-3	323	338	337	1
35	0.90	83	85	82	3	325	338	337	1
40	0.75	58	60	60	-1	299	316	316	0
40	0.75	57	60	61	-1	298	316	315	1
40	0.75	55	60	57	2	300	316	316	0
40	0.80	59	61	58	3	305	318	316	2
40	0.80	59	61	60	0	300	318	320	-2
40	0.80	58	61	62	-2	299	318	318	0
40	0.80	no data	61	57	4	no data	318	315	3
40	0.85	64	61	61	0	311	320	324	-4
40	0.85	59	61	63	-2	305	320	320	1
40	0.85	59	61	58	3	306	320	319	2
40	0.90	66	64	64	0	313	323	329	-6
40	0.90	62	64	66	-2	309	323	323	0
40	0.90	60	64	60	4	313	323	321	3

Notes:
1. Two rawinsondes were launched prior to the cloverleaf mission.
2. The rawinsonde launched at 1522 ZULU reported winds of approximately 352 degrees at 78 knots at 35,000 feet and 307 degrees at 79 knots at 40,000 feet.
3. The rawinsonde launched at 1700 ZULU reported winds of approximately 342 degrees at 103 knots at 35,000 feet and 319 degrees at 69 knots at 40,000 feet.
4. The cloverleaf mission flew between 2038Z and 2222Z.
5. UFTAS - Uniform Flight Test Center Post Test Analysis System.
6. The difference was equal to the cloverleaf result minus the UFTAS result.
7. Aircrew notes recorded the wind speeds and directions calculated by the production F-16 inertial reference unit and production Pitot-static system.
8. F-16B USAF serial number 92-0457.

Table C32 Temperature Results from the Tower Flyby

Flight Date	Time (local)	Instrument-Corrected Pressure Altitude (ft)	Instrument-Corrected Mach Number (n/d)	Production Probe Total Air Temperature (K)	Production Probe Ambient Air Temperature (K)	Flyby Tower Ambient Air Temperature (K)	Correction to be Added to Production Probe (K)	Calibrated Mach Number Squared (n/d)	$5(T_{tic}/T_{a}\text{-}1)$ (n/d)
23-Nov-04	8:25:50	2,164	0.5442	291.3	275.1	274.8	-0.3	0.3009	0.301
23-Nov-04	8:29:38	2,155	0.7021	301.5	274.4	274.8	0.3	0.4995	0.486
23-Nov-04	8:32:53	2,160	0.8527	314.3	274.4	274.7	0.4	0.7340	0.719
23-Nov-04	8:36:33	2,185	0.4730	287.3	275.0	274.9	-0.1	0.2274	0.225
23-Nov-04	9:18:36	2,245	0.3105	280.9	275.6	275.0	-0.6	0.0985	0.108
23-Nov-04	9:23:23	2,238	0.2872	280.5	275.9	275.2	-0.8	0.0838	0.097
23-Nov-04	9:27:45	2,211	0.3933	284.3	275.8	276.7	1.0	0.1577	0.137
23-Nov-04	9:31:39	2,144	0.6304	297.8	275.9	276.9	1.1	0.4038	0.376
23-Nov-04	9:34:54	2,127	0.9078	321.4	276.0	277.1	1.2	0.8312	0.799
23-Nov-04	9:38:19	2,165	0.5492	293.2	276.6	277.3	0.7	0.3066	0.288
23-Nov-04	9:42:00	2,140	0.6201	297.2	276.0	277.4	1.4	0.3908	0.358
23-Nov-04	9:45:35	2,132	0.7016	302.9	275.7	277.5	1.8	0.4990	0.456
23-Nov-04	9:48:56	2,134	0.7719	309.0	276.1	277.6	1.5	0.6032	0.565
23-Nov-04	9:52:08	2,124	0.8117	313.1	276.6	277.8	1.2	0.6663	0.635

Notes: 1. The flyby tower ambient air temperature was determined from the flyby tower data and corrected to the location of the aircraft.

2. The correction to be added to the production probe was equal to the ambient air temperature determined from the flyby tower data minus the ambient air temperature from the production central air data computer (CADC).

3. T_{tic} = total temperature calculated from the ambient temperature output from the CADC assuming a recovery factor of unity.

4. T_a = ambient air temperature determined from the flyby tower data.
measured using the production aircraft total temperature probe.

6. F-16B USAF serial number 92-0457.

7. The recovery factor was determined by a linear regression of the data. The value of the recovery factor was 0.95 and the bias term was 0.0026.

Table C33 Comparison of Calculated Ambient Air Temperatures from the Level Accelerations and Decelerations

Pressure Altitude (1,000 ft)	Calculated Ambient Air Temperature at Beginning of Acceleration (K)	Calculated Ambient Air Temperature at End of Deceleration (K)	Change in Temperature (K)	Rawinsonde Temperature (K)
10	274.5	275.0	0.5	274.2
20	252.6	252.6	0.0	254.3
30	228.2	229.0	0.8	230.4
35	217.8	220.0	2.2	218.4
40	220.6	220.8	0.2	220.9

Notes: 1. The calculated ambient air temperature was the air temperature calculated during the beginning of the acceleration or end of deceleration (when Mach numbers were low) assuming a recovery factor of 1.00.

2. The rawinsonde launch time was 1200Z. The level accelerations were flown at 2200Z.

Table C34 Total Temperature Recovery Factors from the Level Accelerations and Decelerations

Pressure Altitude (1,000 ft)	Ambient Air Temperature Assumed (K)	Ambient Air Temperature Rawinsonde (K)	Recovery Factor (n/d)	Bias Term (n/d)
10	274.5	274.2	0.93	-0.003
20	252.6	254.3	0.88	0.028
30	228.2	230.4	0.91	0.028
35	217.8	218.4	1.03	-0.017
40	220.6	220.9	0.83	0.084
All	N/A	N/A	0.90	0.033

Notes: 1. The assumed air temperature was the air temperature calculated during the beginning of the acceleration (when Mach numbers were low) assuming a recovery factor of 1.00.

2. The rawinsonde launch time was 1200Z. The level accelerations were flown at 2200Z.

3. The bias term was equal to $5(T_{tic}/T_a-1)$ at zero Mach number.

where:

a. T_{tic} = total air temperature corrected for instrument errors.

b. T_a = ambient air temperature.

4. The assumed ambient air temperature was used in this analysis.

5. Only the acceleration data were used in the analyses at 10K through 40K. The deceleration data were not used.

6. The "All" analysis used data from both the accelerations and decelerations, but only at 10K, 20K, 30K, and 40K. The recovery factor and bias term were calculated using all of the data from the four altitudes in the linear regression. The 35K data were not used because there was an apparent change in ambient air temperature during the acceleration and deceleration.

7. The data are for flight test total temperature probe.

8. n/d - nondimensional.

9. N/A - not applicable

Table C35 Rawinsonde Temperature Data from the Cloverleaf Test Points

Approximate Time at Altitude (ZULU)	Geometric Altitude (ft)	Ambient Air Temperature (K)
16:00	35,000	220.5
	36,000	219.2
	40,000	217.0
	41,000	214.9
17:40	35,000	217.4
	36,000	217.0
	40,000	214.6
	41,000	212.7
21:00	40,000	210.2
	41,000	208.3
22:00	35,000	211.6
	36,000	211.2

Notes: 1. The test points at 40K were flown between 2038Z and 2140Z.
2. The test points at 35K were flown between 2145Z and 2220Z.
3. The ambient air temperatures at 2100 and 2200 ZULU were estimated by extrapolating the temperatures from the 1600 and 1740 ZULU balloon data. The temperatures were extrapolated from the 1740 data using a rate of -0.022K per minute.

Table C36 Total Air Temperature Probe Recovery Factor Data from the Cloverleaf Test Points

Geometric Altitude (ft)	Total Air Temperature (K)	Instrument Corrected Mach Number (n/d)	Mach Number Squared (n/d)	Rawinsonde Ambient Air Temperature at 17:40 (K)	$5(T_{tic}/T_{a-1})$ (n/d)	Extrapolated Rawinsonde Ambient Air (K)	$5(T_{tic}/T_{a-1})$ (n/d)
35,580	241.6	0.7987	0.6379	217.1	0.5633	211.4	0.7138
35,577	241.3	0.7984	0.6375	217.1	0.5578	211.4	0.7081
35,579	241.4	0.7988	0.6381	217.1	0.5602	211.4	0.7106
35,561	244.7	0.8483	0.7196	217.1	0.6354	211.4	0.7879
35,557	244.7	0.8485	0.7199	217.1	0.6343	211.4	0.7868
35,564	244.8	0.8487	0.7203	217.1	0.6369	211.4	0.7894
35,540	248.0	0.8984	0.8071	217.1	0.7098	211.4	0.8643
35,540	247.9	0.8983	0.8070	217.1	0.7096	211.4	0.8641
35,546	247.9	0.8979	0.8062	217.1	0.7091	211.4	0.8636
40,397	234.5	0.7030	0.4942	213.8	0.4840	209.4	0.5992
40,404	234.0	0.7022	0.4930	213.8	0.4725	209.4	0.5875
40,408	234.0	0.7022	0.4930	213.8	0.4733	209.4	0.5883
40,394	240.5	0.8014	0.6423	213.8	0.6247	209.4	0.7429
40,399	240.8	0.8057	0.6491	213.8	0.6322	209.4	0.7505
40,402	240.5	0.8071	0.6514	213.8	0.6256	209.4	0.7438
40,400	240.5	0.8045	0.6472	213.8	0.6257	209.4	0.7439
40,375	242.7	0.8473	0.7180	213.8	0.6737	209.4	0.7929
40,375	243.4	0.8465	0.7165	213.8	0.6919	209.4	0.8115
40,384	243.0	0.8446	0.7134	213.8	0.6828	209.4	0.8022
40,354	245.2	0.8983	0.8069	213.9	0.7317	209.5	0.8521
40,344	245.8	0.8989	0.8080	213.9	0.7468	209.5	0.8675
40,355	245.8	0.8953	0.8016	213.9	0.7474	209.5	0.8681

Notes: 1. The geometric altitude data was from the ARDS pod.

2. The total air temperature was measured by the flight test total temperature probe.

3. The rawinsonde was launched at 1700 ZULU on 21 December 2004 and was assumed to be at 35,000 to 40,000 feet at approximately 1740.

4. In the parameter $5(T_{tic}/T_{a-1})$, T_{tic} was the total air temperature and T_a was the ambient air temperature from the rawinsonde.

5. The extrapolated rawinsonde ambient air temperature was extrapolated in time from 1740 to 2100 for the 40K test points and to 2200 for the 35K test points.

6. n/d - nondimensional

Table C37 Total Temperature Recovery Factors from the Cloverleaf Test Points

Pressure Altitude (1,000 ft)	Data Source for Ambient Air Temperature	Recovery Factor (n/d)	Bias Term (n/d)
35	1700 Rawinsonde	0.88	-0.002
40		0.86	0.062
35	Extrapolated Data	0.91	0.134
40		0.88	0.168

Notes: 1. The assumed air temperature was the air temperature calculated during the beginning of the acceleration (when Mach numbers were low) assuming a recovery factor of 1.00.

2. The rawinsonde launch time was 1200Z. The level accelerations were flown at 2200Z.

3. The bias term was equal to $5(T_{tic}/T_a-1)$ at zero Mach number.

4. T_{tic} = total air temperature corrected for instrument errors.

5. T_a = ambient air temperature.

6. The assumed ambient air temperature was used in this analysis.

7. Only the acceleration data were used in the analyses at 10K through 40K. The deceleration data were not used.

8. The "All" analysis used data from both the accelerations and decelerations, but only at 10K, 20K, 30K, and 40K. The recovery factor and bias term were calculated using all of the data from the four altitudes in the linear regression. The 35K data were not used because there was an apparent change in ambient air temperature during the acceleration and deceleration.

9. The data are for flight test total temperature probe.

10. n/d - nondimensional

Table C38 Angle of Attack Corrections to be Added to the Production Angle of Attack Based on the GPS Cloverleaf Test Points

Pressure Altitude (ft)	Mach Number (n/d)	Indicated Angle of Attack (deg)	ARDS Pitch Angle (deg)	True Angle of Attack (deg)	Correction Based on Pitch Angle (deg)	Correction Based on True Angle of Attack (deg)
35,002	0.7987	3.76	3.82	3.82	0.06	0.06
35,001	0.7984	3.73	3.90	3.93	0.16	0.20
35,003	0.7988	3.69	3.70	3.68	0.01	-0.01
34,997	0.8483	3.22	3.30	3.30	0.08	0.09
34,996	0.8485	3.17	3.30	3.33	0.12	0.15
34,998	0.8487	3.14	3.19	3.17	0.05	0.02
34,990	0.8984	2.73	2.70	2.71	-0.03	-0.02
34,992	0.8983	2.69	2.65	2.67	-0.04	-0.02
34,995	0.8979	2.65	2.60	2.56	-0.05	-0.09
39,897	0.7030	7.56	7.44	7.46	-0.11	-0.09
39,899	0.7022	7.46	7.41	7.44	-0.05	-0.02
39,899	0.7022	7.32	7.20	7.18	-0.12	-0.13
39,901	0.8014	5.61	5.72	5.73	0.11	0.11
39,903	0.8057	5.44	5.54	5.56	0.09	0.12
39,904	0.8071	5.34	5.33	5.31	-0.01	-0.03
39,901	0.8014	5.61	5.72	5.73	0.11	0.11
39,903	0.8057	5.44	5.54	5.56	0.09	0.12
39,904	0.8045	5.32	5.39	5.39	0.07	0.06
39,901	0.8473	4.96	5.15	5.16	0.19	0.20
39,902	0.8465	4.89	5.02	5.04	0.13	0.16
39,903	0.8446	4.81	4.88	4.85	0.07	0.05
39,888	0.8981	4.23	4.34	4.36	0.11	0.13
39,889	0.8988	4.16	4.10	4.12	-0.05	-0.04
39,890	0.8953	4.13	4.15	4.12	0.02	-0.01

Notes: 1. F-16B USAF serial number 92-0457.
2. The flaps and landing gear were retracted. Advanced range data system (ARDS) pod on station 1, 370 gallon fuel tanks on stations 4 and 6.
3. The indicated angles of attack were measured by the production aircraft angle of attack system.
4. The pitch angles were measured by the ARDS pod mounted on station 1. The pitch angles were not corrected for wing twist.
5. The true angles of attack were calculated using the Air Force Post-Test Analysis System (APTAS), and were based on the inertial data measured by the ARDS pod.
6. The corrections are corrections to be added to the indicated angles of attack.
7. These data were from the GPS cloverleaf test points flown on 21 December 2004.
8. ARDS - Advanced Range Data System

Table C39 Angle of Attack Corrections to be Added to the
Production Angles of Attack Based on the C-17 Cross-Pace Test Points

Time (ZULU)	Pressure Altitude (ft)	Indicated Angle of Attack (deg)	True Angle of Attack (deg)	Correction (deg)
23:36:13	9,941	8.0	7.9	-0.1
23:34:11	9,928	5.2	5.2	-0.1
23:32:29	9,923	4.2	4.2	0.0
23:27:26	9,924	2.7	2.7	0.0
23:30:36	9,910	2.7	2.8	0.1
23:25:45	9,918	2.5	2.4	-0.1
23:16:49	19,939	6.6	6.2	-0.4
23:14:33	19,928	4.4	4.2	-0.1
23:12:53	19,925	3.6	3.5	-0.1
23:10:39	19,940	3.0	2.8	-0.2
23:08:33	19,936	2.5	2.3	-0.2
22:59:23	29,907	7.2	7.0	-0.2
22:57:45	29,900	6.0	5.8	-0.1
22:55:46	29,908	5.0	4.9	-0.1
22:54:03	29,908	4.2	4.2	0.0
22:50:30	29,910	3.6	3.5	-0.1
22:39:45	34,897	9.2	8.9	-0.3
22:38:00	34,899	8.1	7.9	-0.2
22:36:07	34,902	6.8	6.7	0.0
22:32:02	34,914	5.8	5.7	-0.1
22:30:18	34,908	4.8	4.8	0.0
22:22:19	39,899	9.0	8.6	-0.4
22:20:53	39,903	8.4	8.0	-0.3
22:19:03	39,910	7.5	7.3	-0.2

Notes: 1. F-16B USAF serial number 92-0457.
2. The flaps and landing gear were retracted. Advanced range data system (ARDS) pod on station 1, 370 gallon fuel tanks on stations 4 and 6.
3. The indicated angles of attack were measured by the production aircraft angle of attack system.
4. The true angles of attack were calculated using the Air Force Post-Test by the ARDS pod. The pitch angles from the ARDS pod were not corrected for wing twist.
5. These test points were flown on 31 March 2005.
6. ARDS - Advanced Range Data System

Table C40 Comparison of Radar Altitude and ARDS Altitude with Flyby Tower Measurements

Flight Date	Time (local)	Instrument-Corrected		Height AGL from Tower Grid Readings (ft AGL)	Radar Altitude (ft AGL)	Correction to Radar Altitude (ft)	ARDS Geometric Altitude (ft MSL)	Height AGL from ARDS Geometric Altitude (ft AGL)	Correction to ARDS Height AGL (ft)
		Pressure Altitude (ft)	Airspeed (kts)						
23-Nov-04	8:25:50	2,164	347.0	119	116	3	2,390	119	0
23-Nov-04	8:29:38	2,155	448.4	138	139	-1	2,411	140	-2
23-Nov-04	8:32:53	2,160	545.4	144	144	1	2,415	144	1
23-Nov-04	8:36:33	2,185	301.3	122	119	4	2,391	120	2
23-Nov-04	9:18:36	2,245	197.4	154	151	3	2,422	151	3
23-Nov-04	9:23:23	2,238	182.5	138	139	-1	2,407	137	2
23-Nov-04	9:27:45	2,211	250.2	144	144	1	2,411	141	4
23-Nov-04	9:31:39	2,144	402.4	135	136	-1	2,403	132	3
23-Nov-04	9:34:54	2,127	581.3	122	131	-9	2,394	123	-1
23-Nov-04	9:38:19	2,165	350.2	132	134	-2	2,404	133	-1
23-Nov-04	9:42:00	2,140	395.8	129	126	2	2,397	126	2
23-Nov-04	9:45:35	2,132	448.3	129	129	0	2,398	127	2
23-Nov-04	9:48:56	2,134	493.5	138	141	-3	2,407	136	2
23-Nov-04	9:52:08	2,124	519.3	129	129	0	2,400	129	-1

Notes:
1. AGL - above ground level.
2. MSL - mean sea level.
3. Elevation of the flyby line in the national vertical datum of 1929 was 2,271 feet.
4. Elevation of the zero grid line of the flyby tower in the national vertical datum of 1929 was 2,305 feet.
5. Height AGL from the Advanced range data system (ARDS) pod was equal to the ARDS altitude minus 2,271 feet.
6. The height AGL from the tower grid reading was equal to (2,305 - 2,271) + [31.48 (grid reading)]
7. F-16B USAF serial number 92-0457.
8. The flaps and landing gear were retracted. ARDS pod on station 1, 370 gallon fuel tanks on stations 4 and 6.
9. The pressure altitude and airspeed were calculated using the instrument-corrected pressures from the Dual Sonix digital pressure encoders.
10. Corrections were corrections to be added and were equal to the flyby tower results minus the radar altitudes or the ARDS results.
11. The radar altitudes were corrected upward by 30 inches to account for the difference in height between the radar altimeter antennae and the spot on the fuselage targeted by the flyby tower operator.
12. ARDS - Advanced Range Data System

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Dual Sonix Digital Pressure Encoder Laboratory Calibration Results

Serial Number 8, Static Pressure
F-16B Pacer, System 1
November 2004

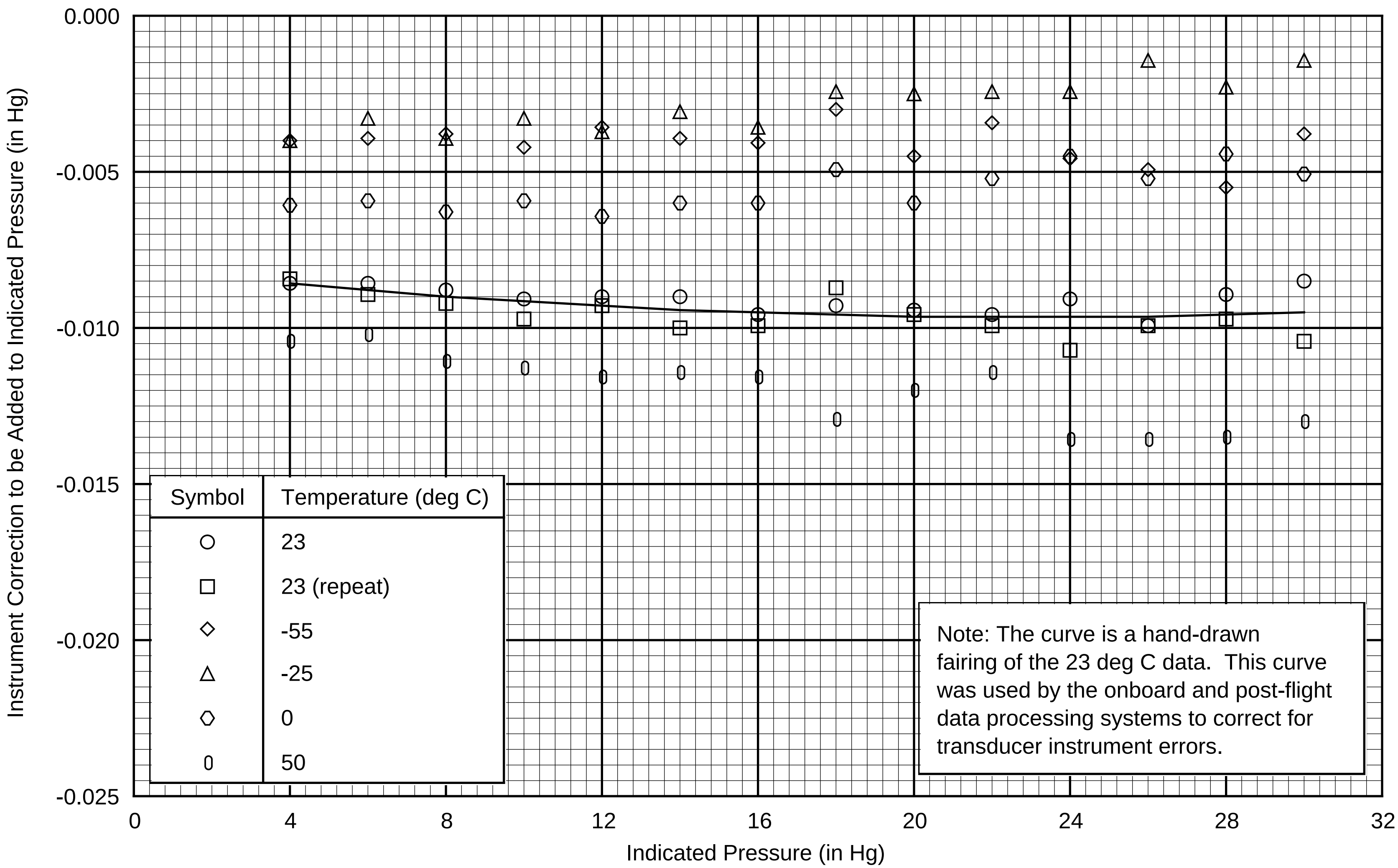

Figure C1 Instrument Error Corrections for Pacer System 1 Static Pressure

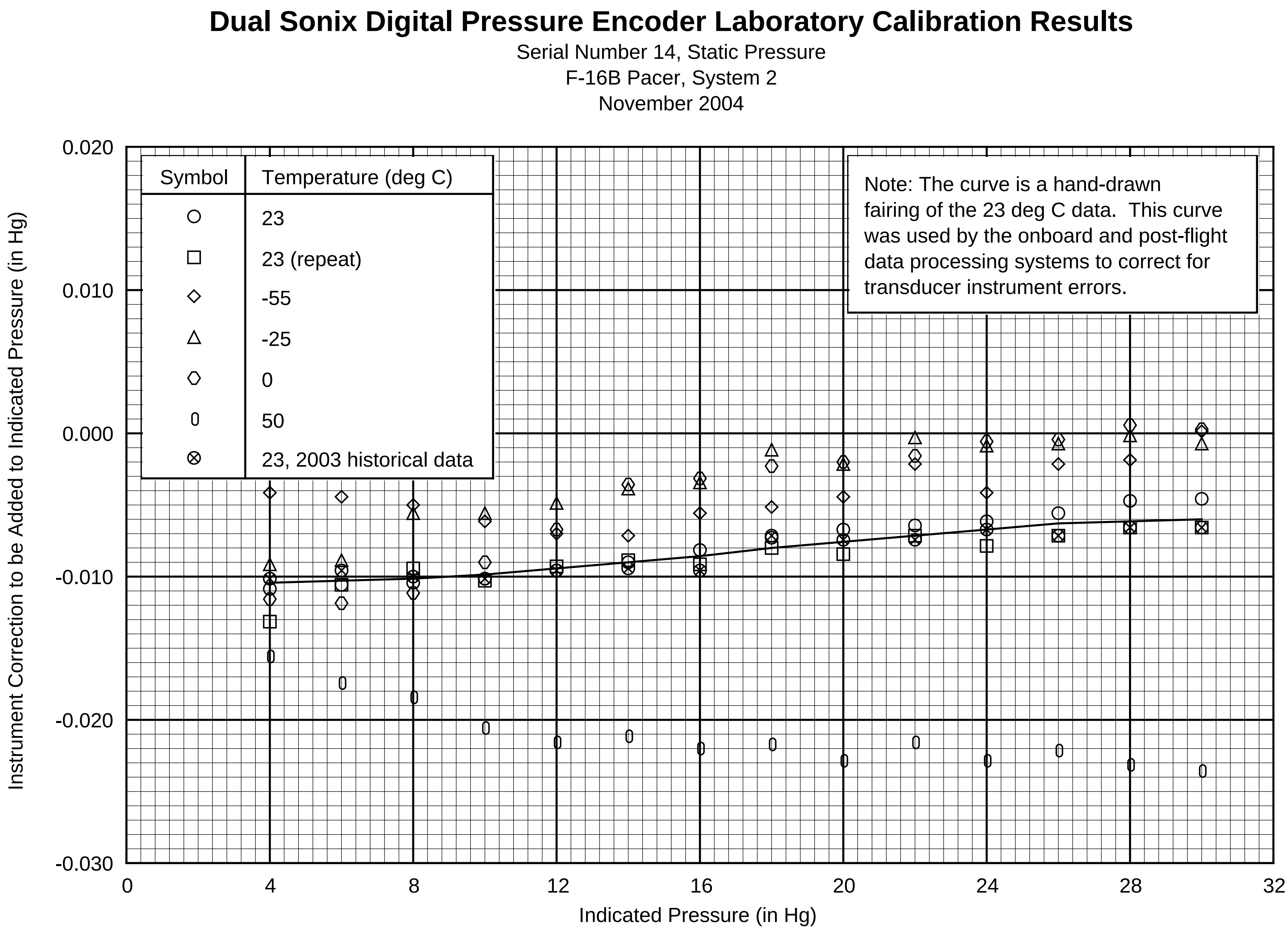

Figure C2 Instrument Error Corrections for Pacer System 2 Static Pressure

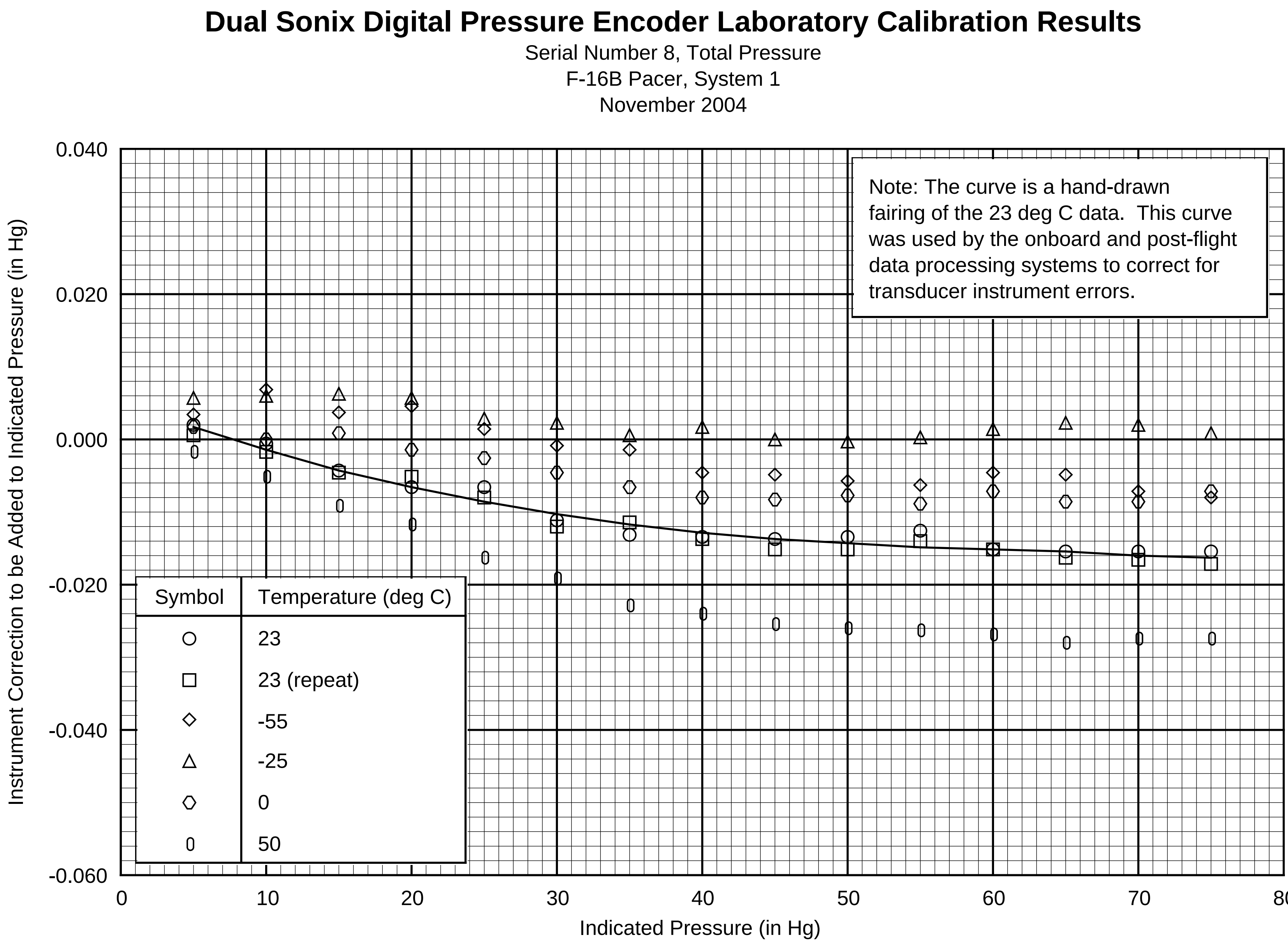

Figure C3 Instrument Error Corrections for Pacer System 1 Total Pressure

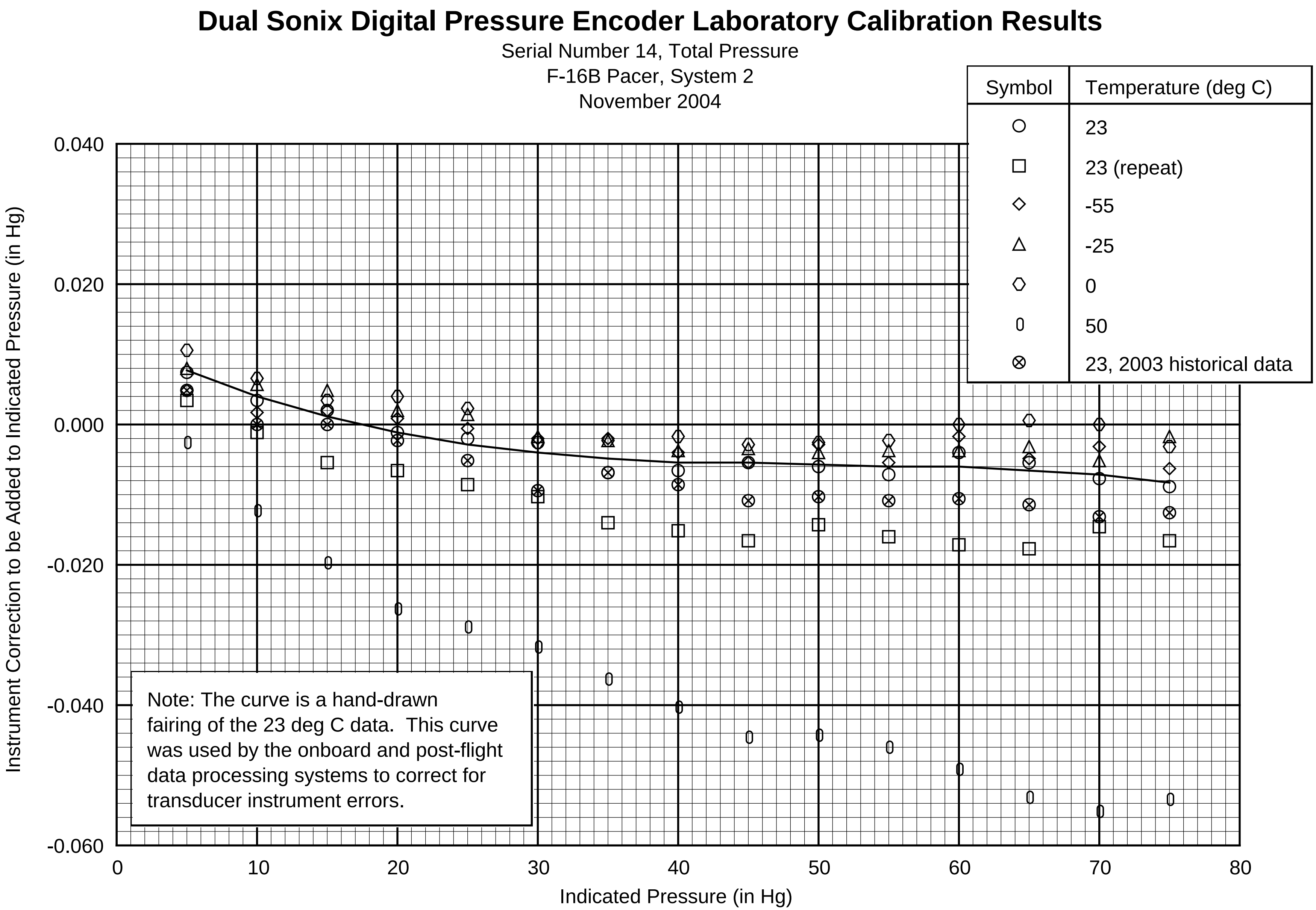

Figure C4 Instrument Error Corrections for Pacer System 2 Total Pressure

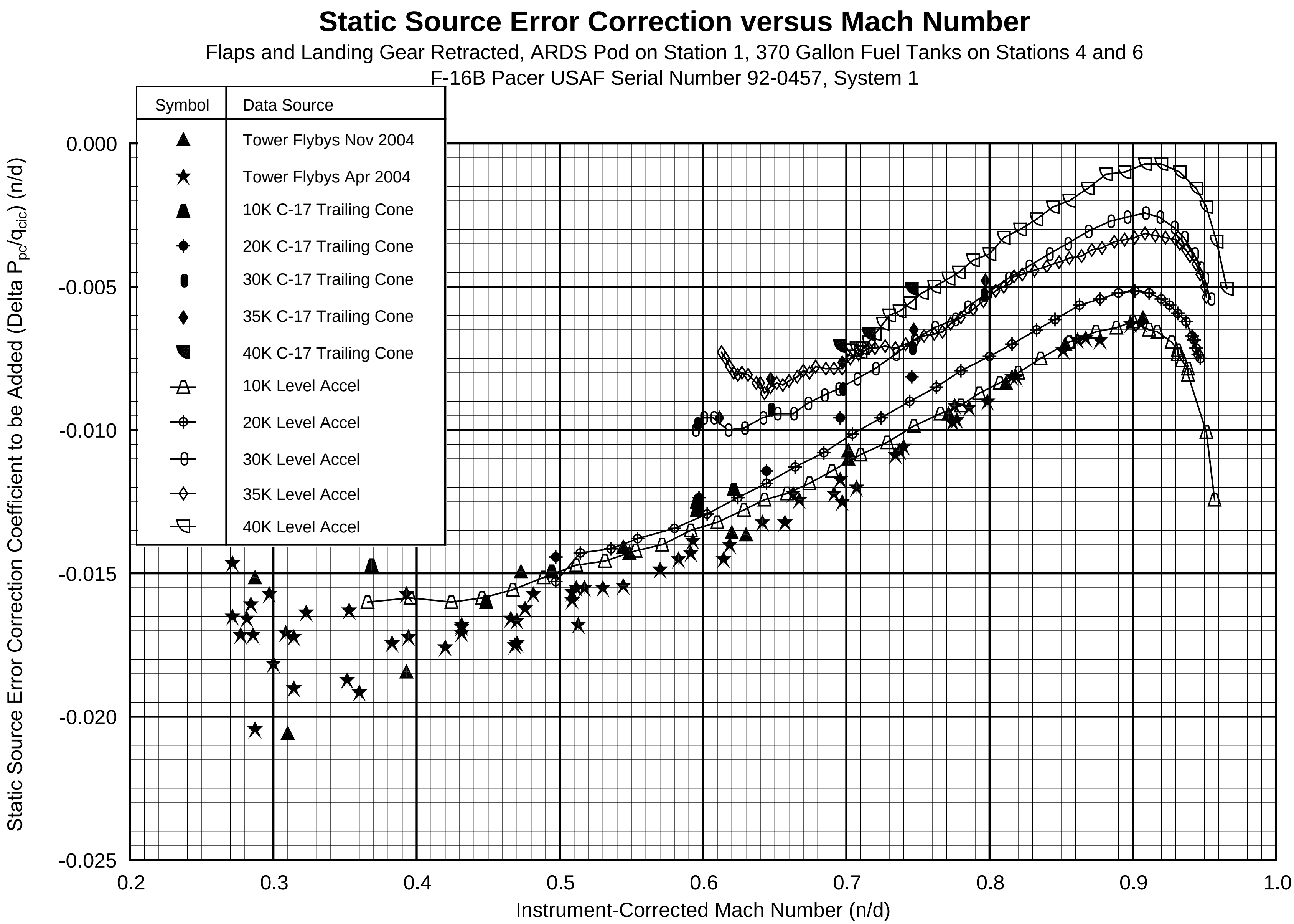

Figure C5 Static Source Error Correction versus Mach Number

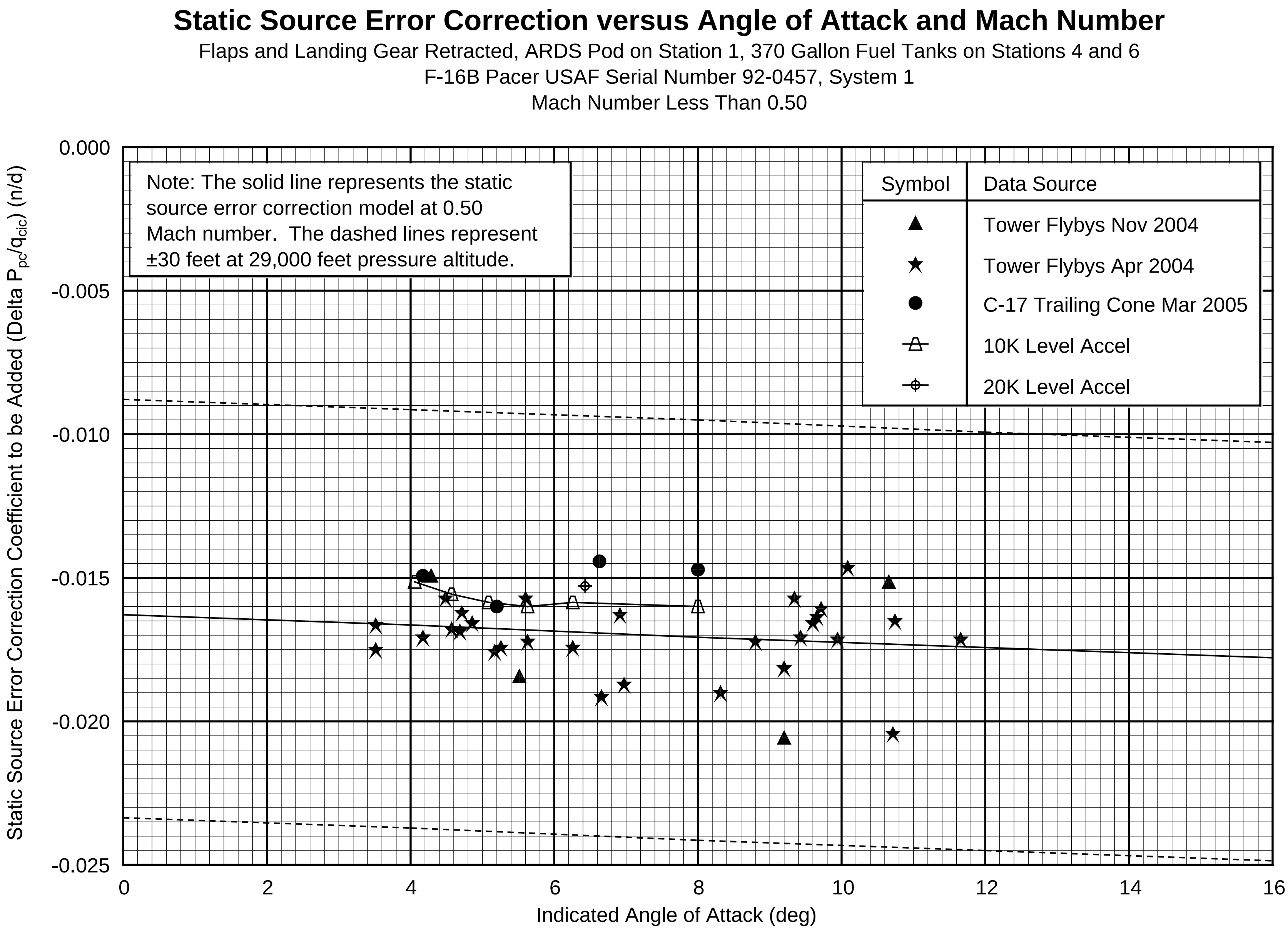

Figure C6 Static Source Error Corrections for Mach Numbers Less Than 0.50

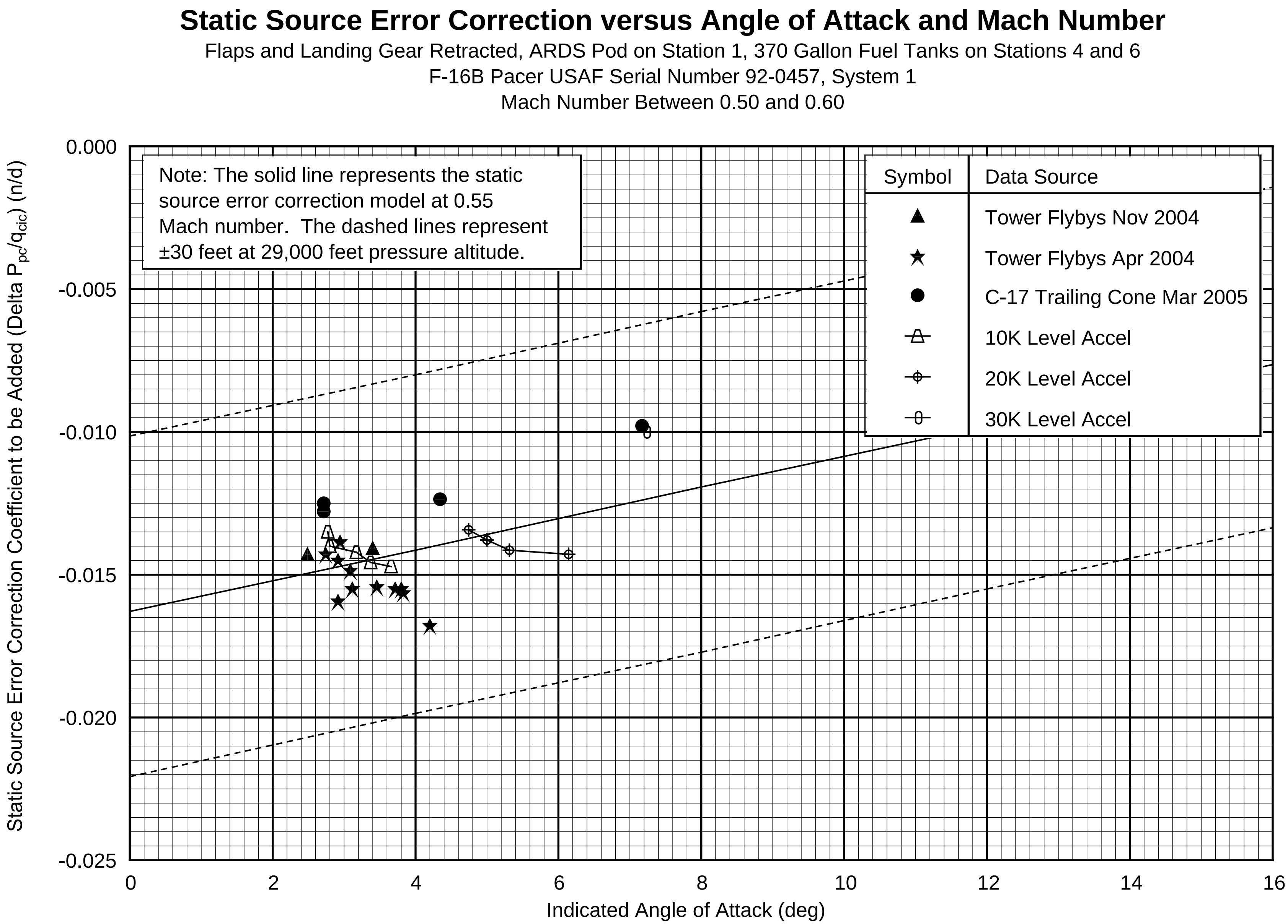

Figure C7 Static Source Error Corrections for Mach Numbers Between 0.50 and 0.60

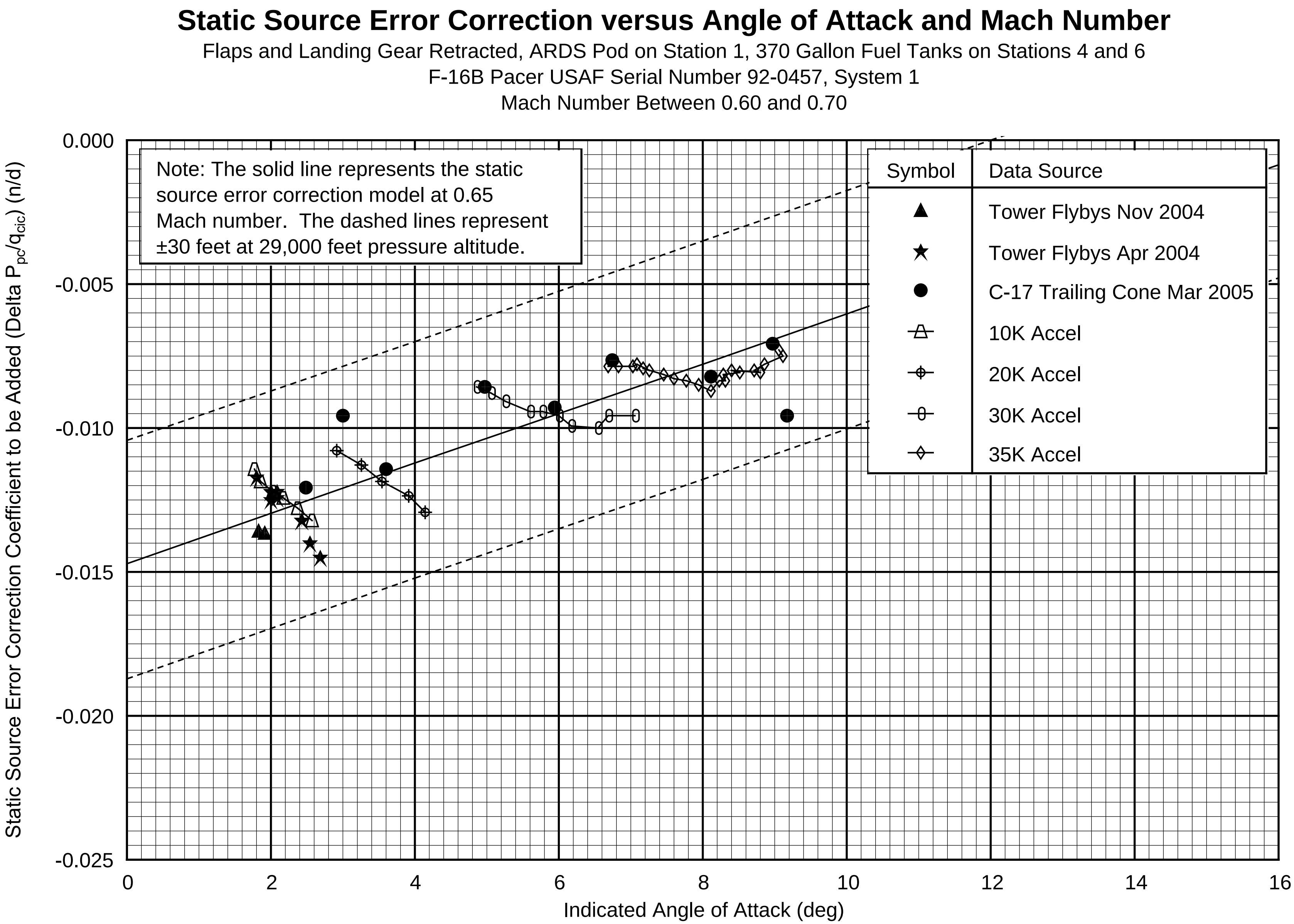

Figure C8 Static Source Error Corrections for Mach Numbers Between 0.60 and 0.70

Static Source Error Correction versus Angle of Attack and Mach Number

Flaps and Landing Gear Retracted, ARDS Pod on Station 1, 370 Gallon Fuel Tanks on Stations 4 and 6
F-16B Pacer USAF Serial Number 92-0457, System 1
Mach Number Between 0.70 and 0.80

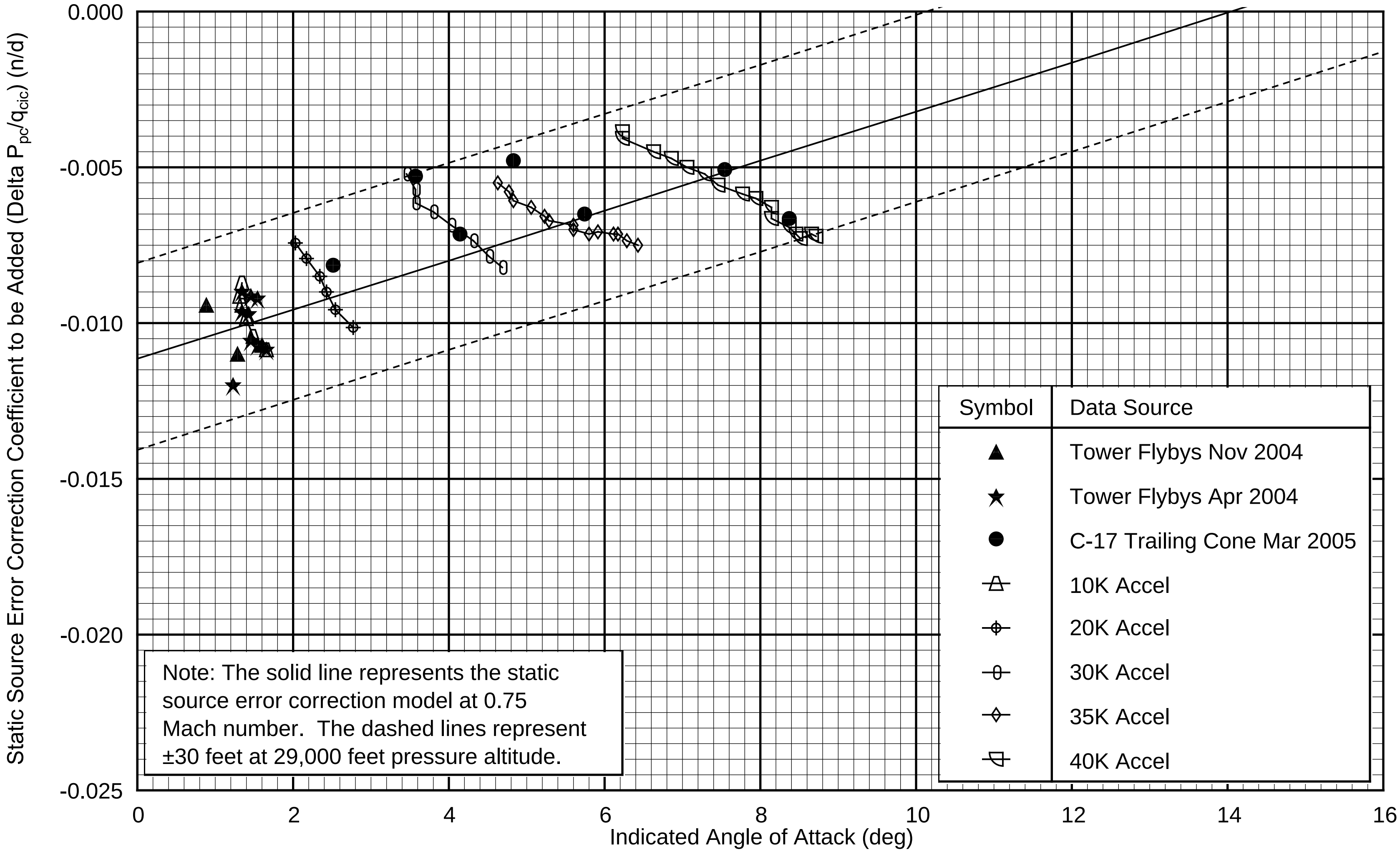

Figure C9 Static Source Error Corrections for Mach Numbers Between 0.70 and 0.80

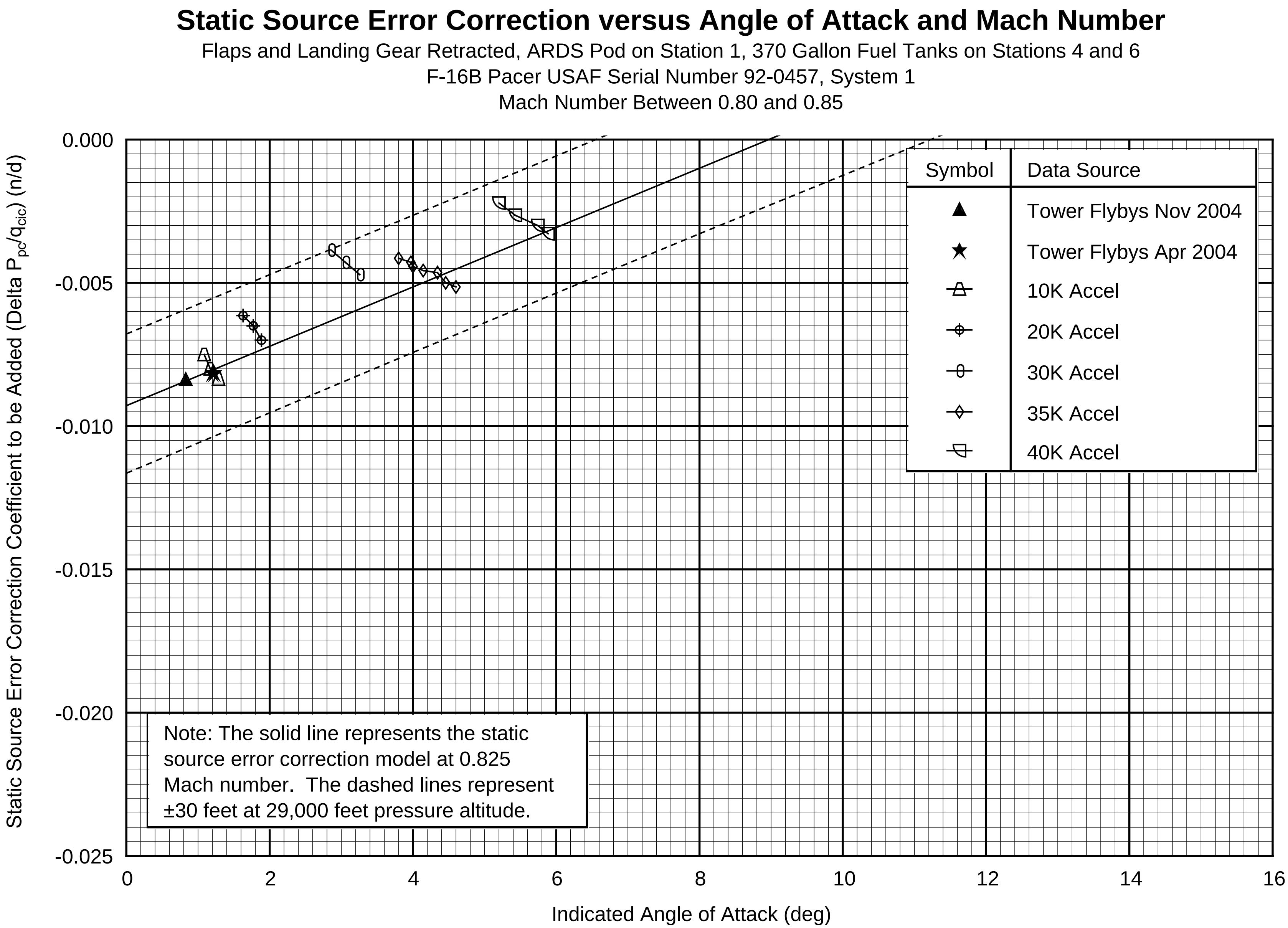

Figure C10 Static Source Error Corrections for Mach Numbers Between 0.80 and 0.85

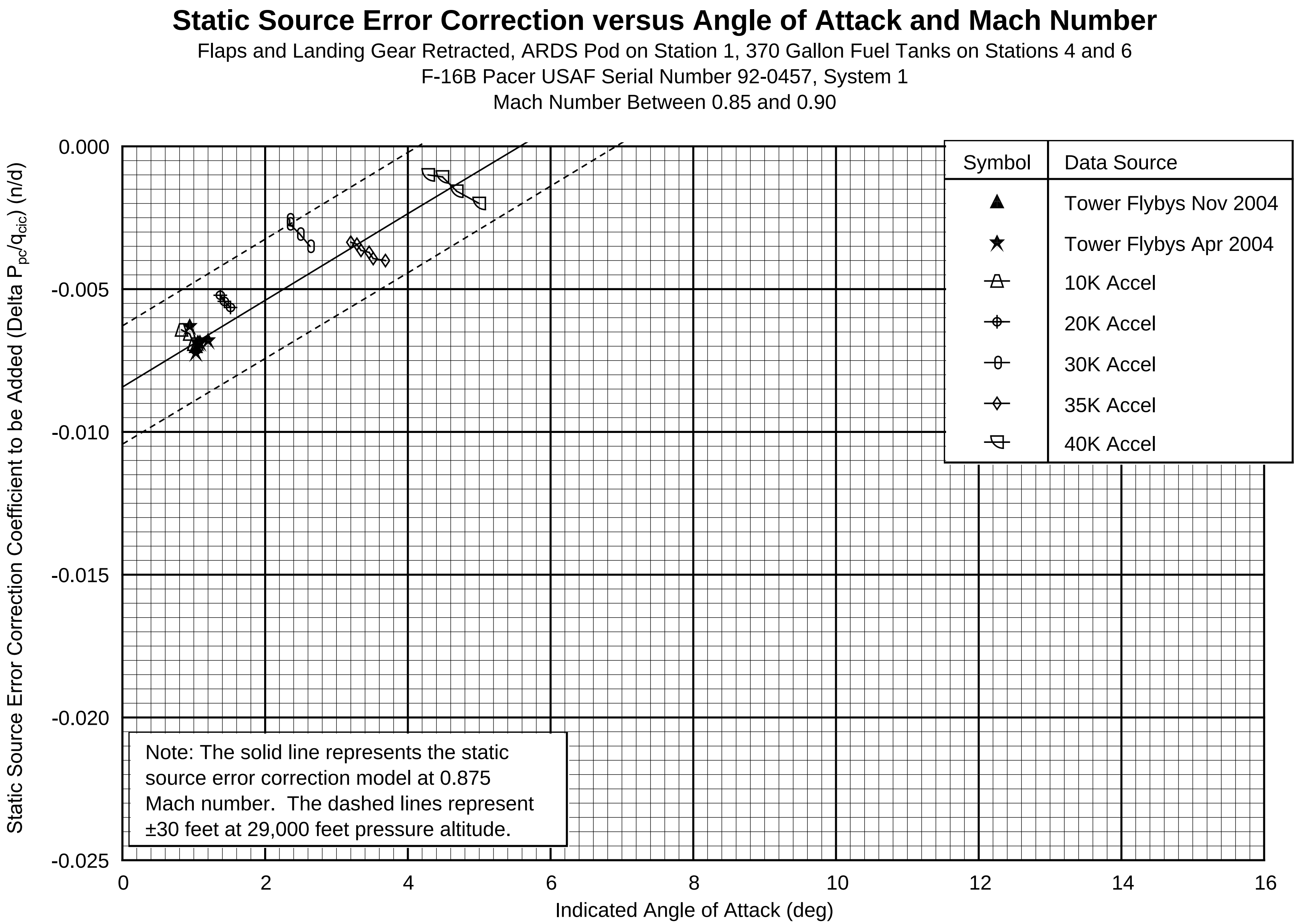

Figure C11 Static Source Error Corrections for Mach Numbers Between 0.85 and 0.90

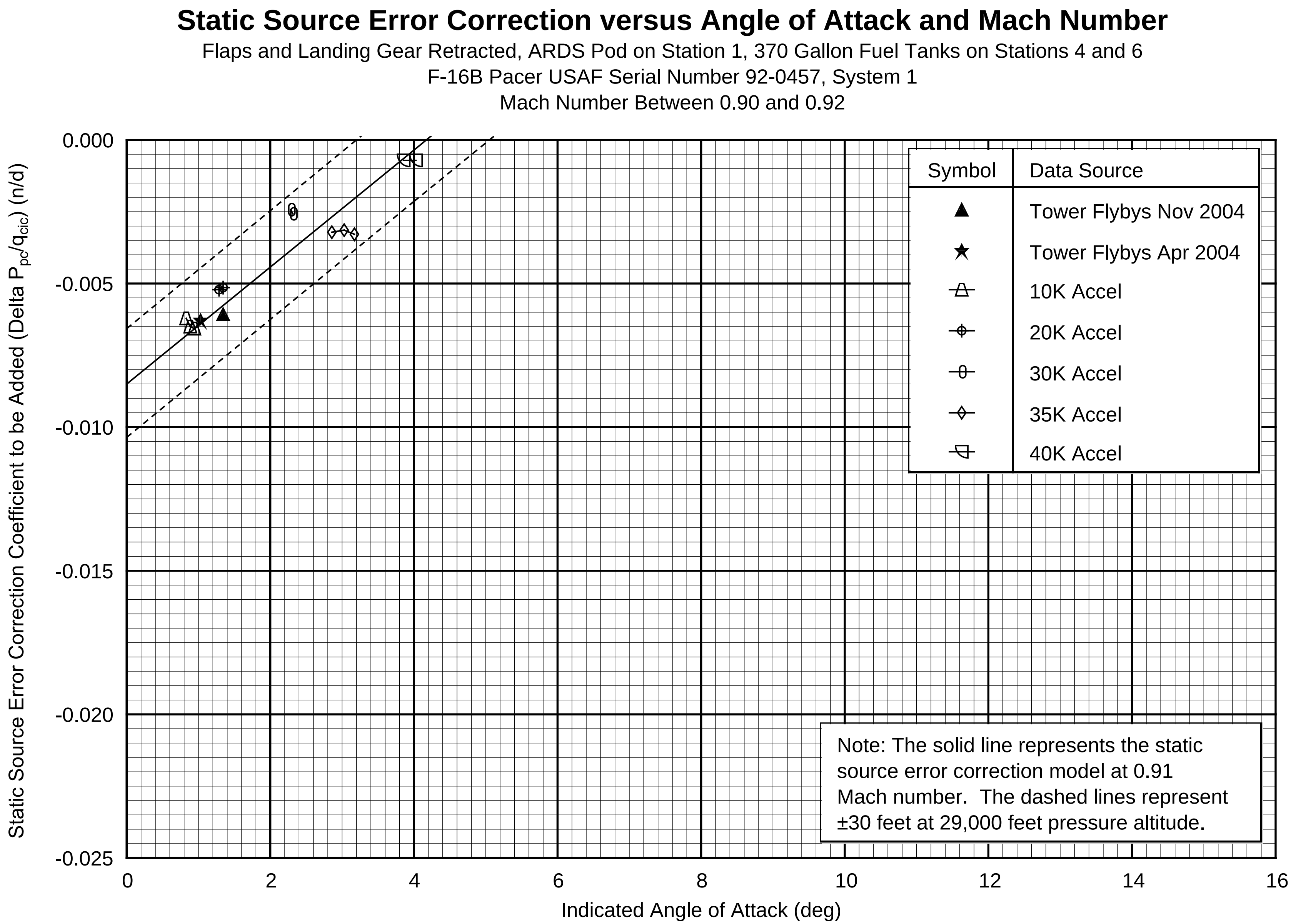

Figure C12 Static Source Error Corrections for Mach Numbers between 0.90 and 0.92

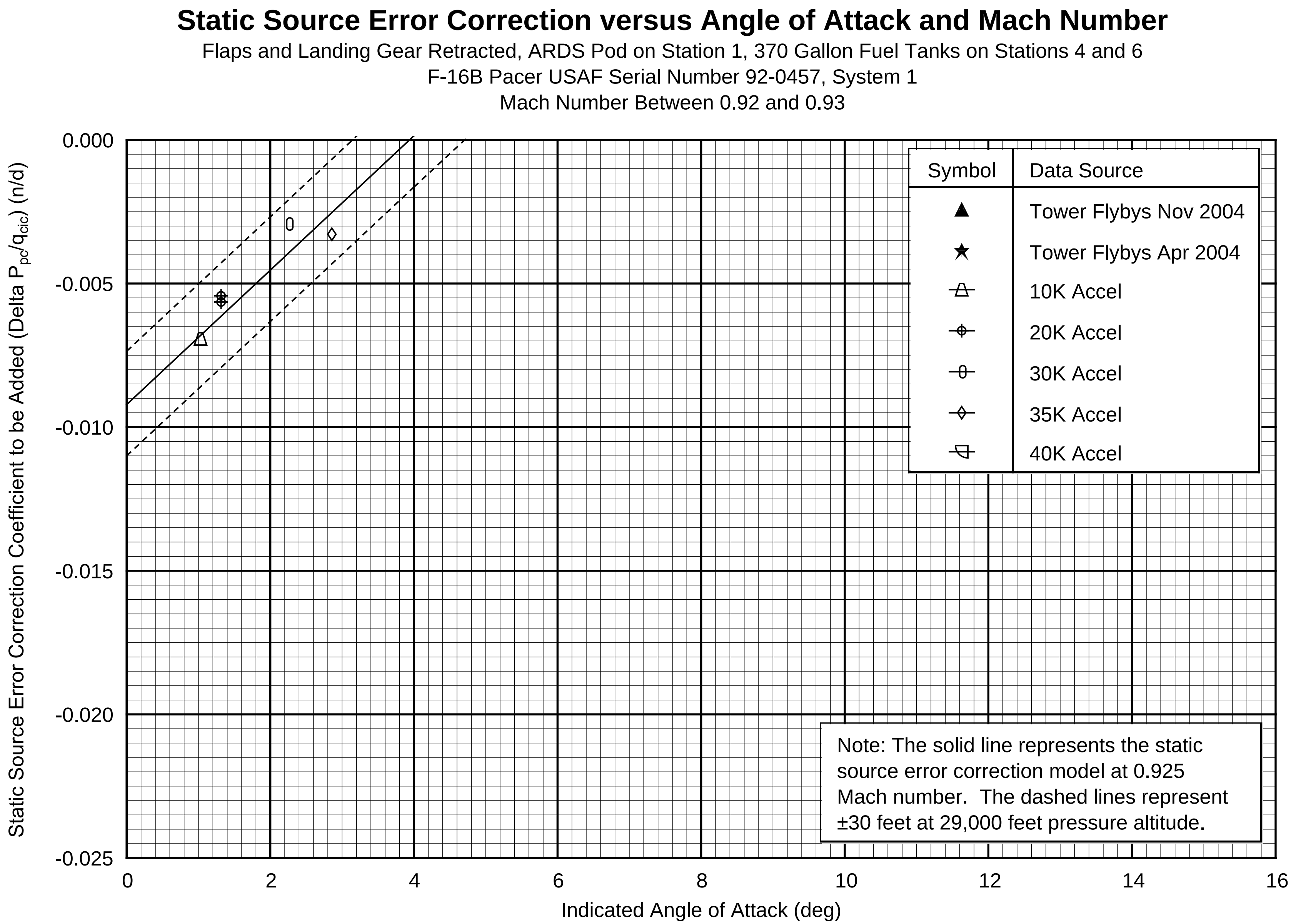

Figure C13 Static Source Error Corrections for Mach Numbers between 0.92 and 0.93

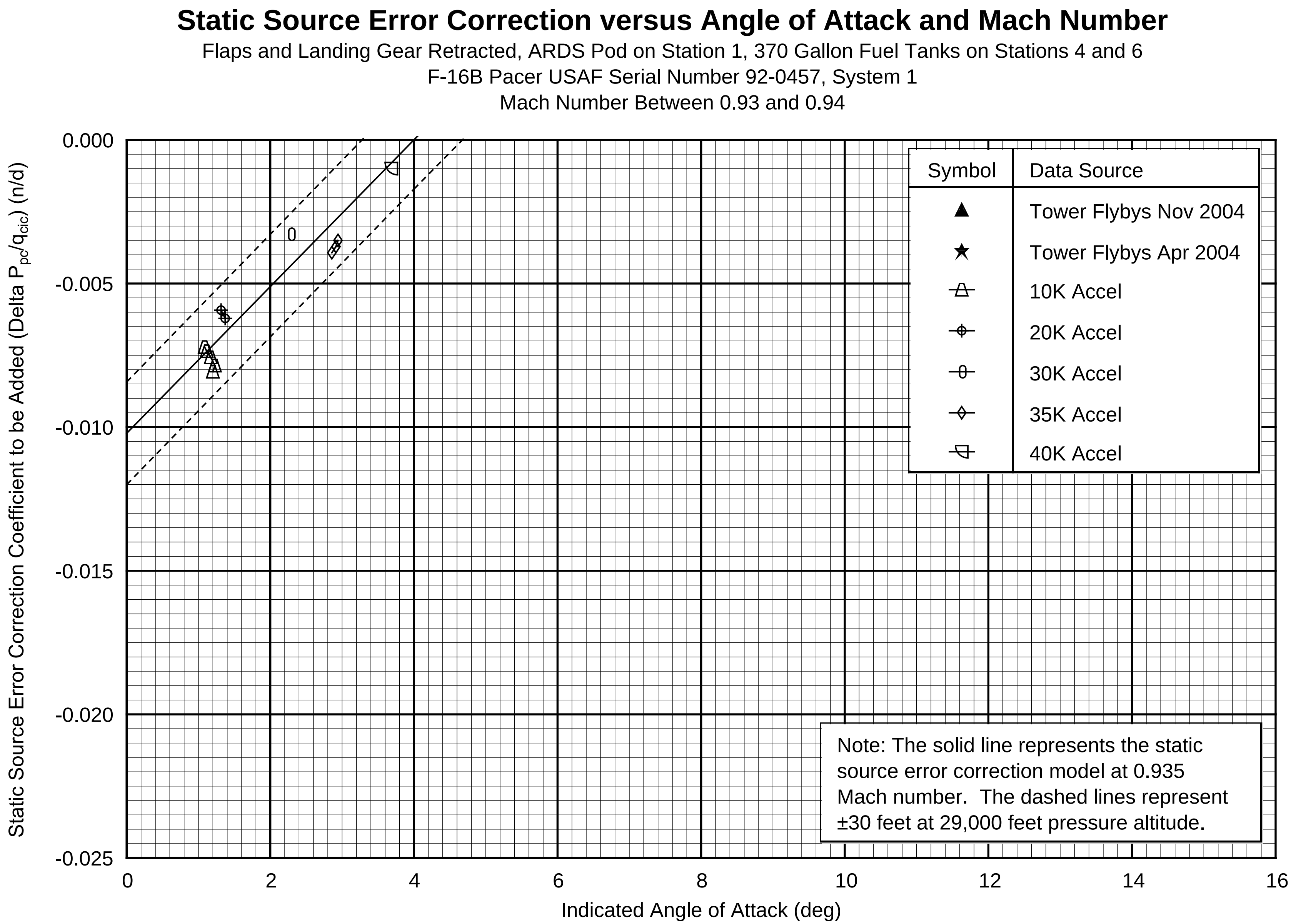

Figure C14 Static Source Error Corrections for Mach Numbers between 0.93 and 0.94

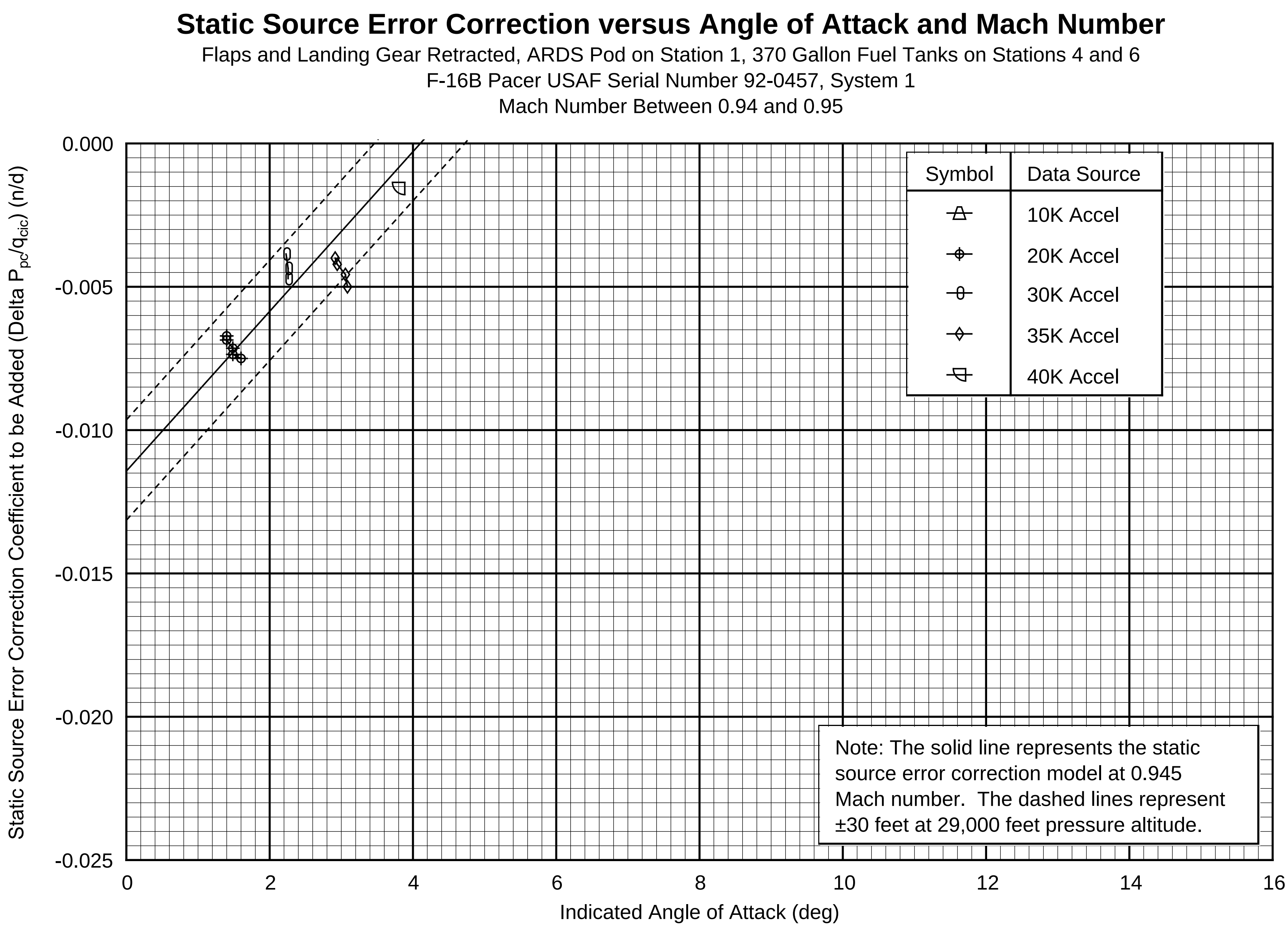

Figure C15 Static Source Error Corrections for Mach Numbers between 0.94 and 0.95

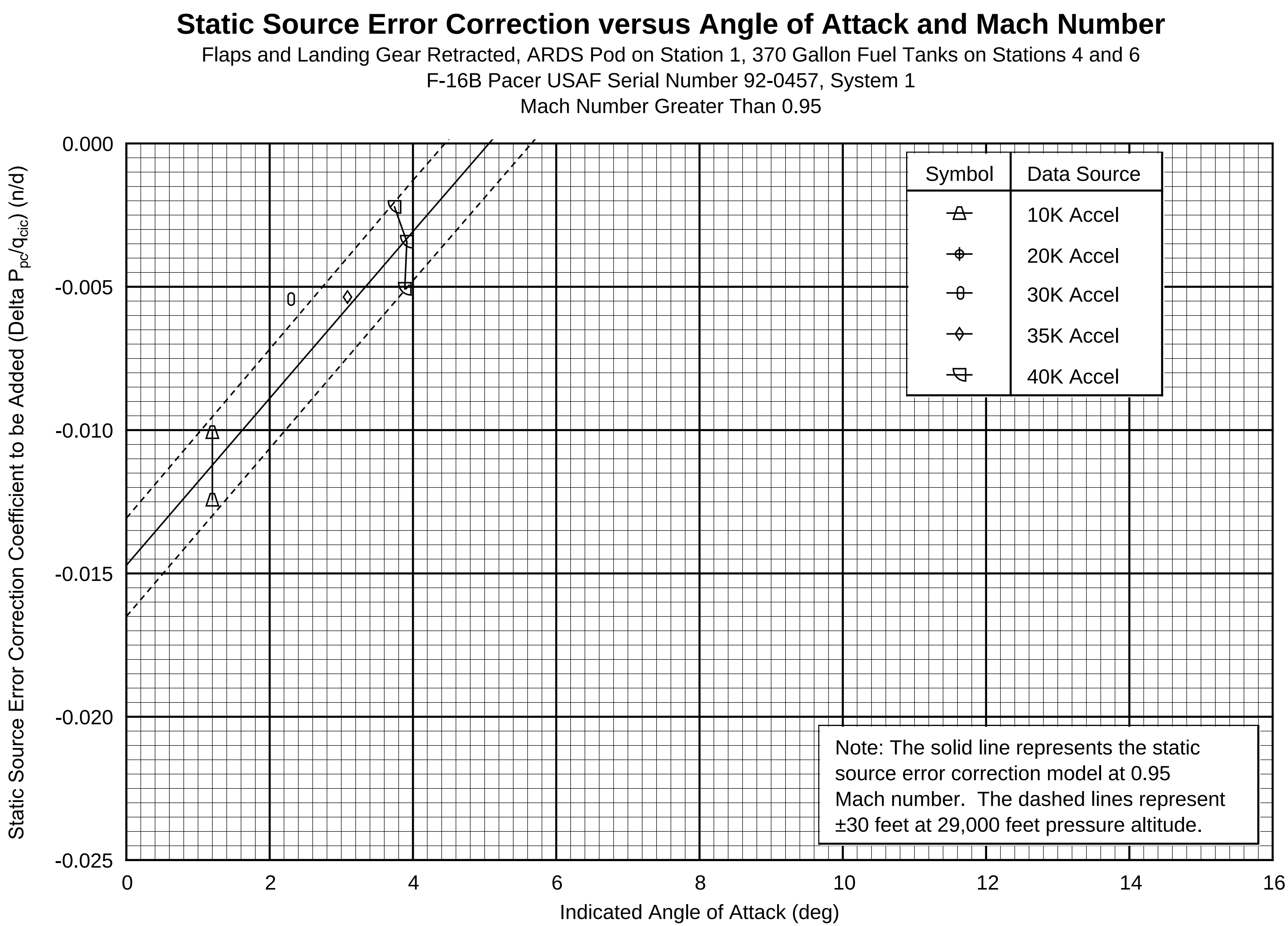

Figure C16 Static Source Error Corrections for Mach Numbers Greater Than 0.95

Delta Static Source Error Correction Coefficient versus Mach Number

Flaps and Landing Gear Retracted, ARDS Pod on Station 1, 370 Gallon Fuel Tanks on Stations 4 and 6
F-16B Pacer USAF Serial Number 92-0457, System 1

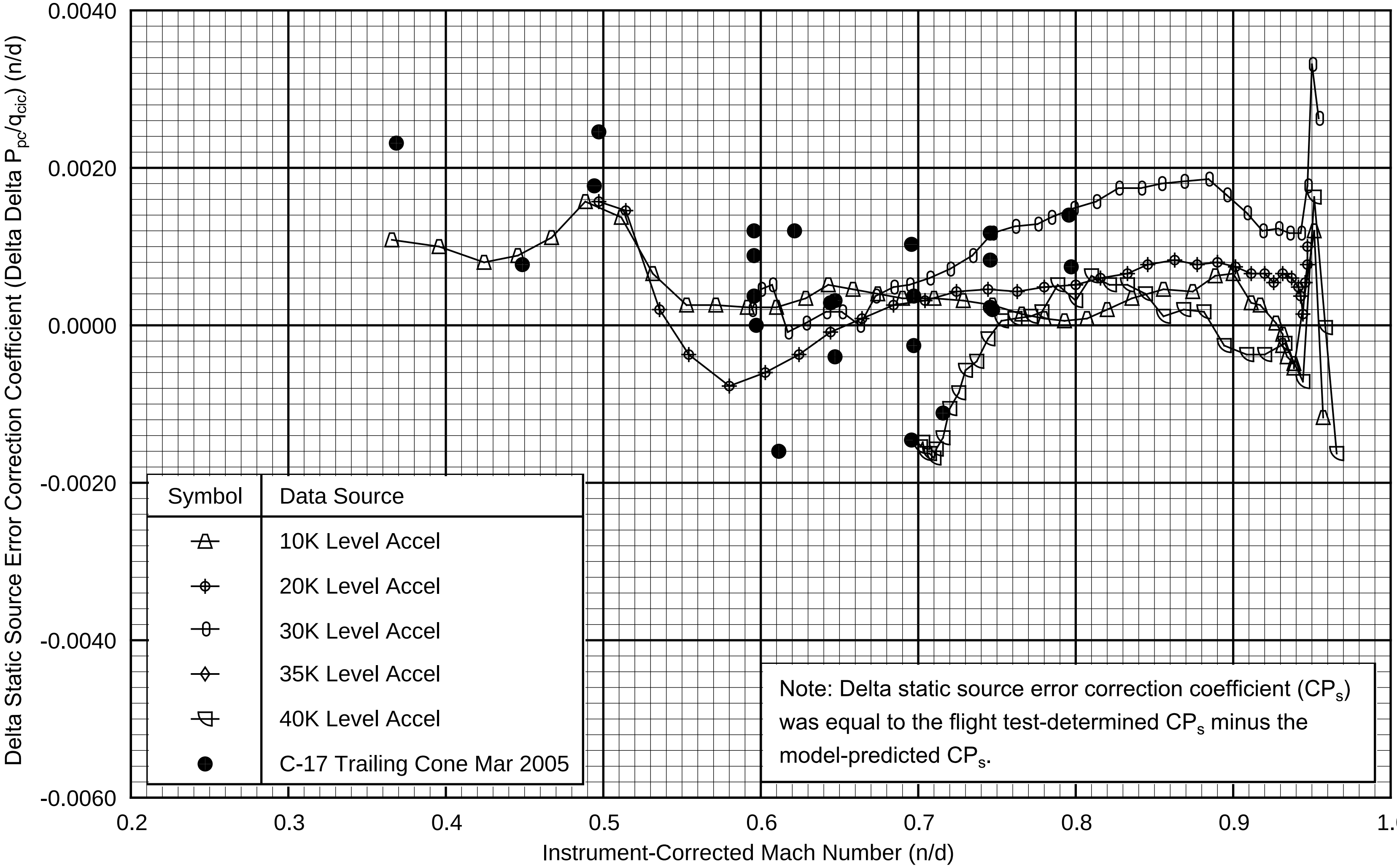

Figure C17 Comparison Between Flight Test Static Source Error Correction and Model - Static Source Error Correction Coefficient

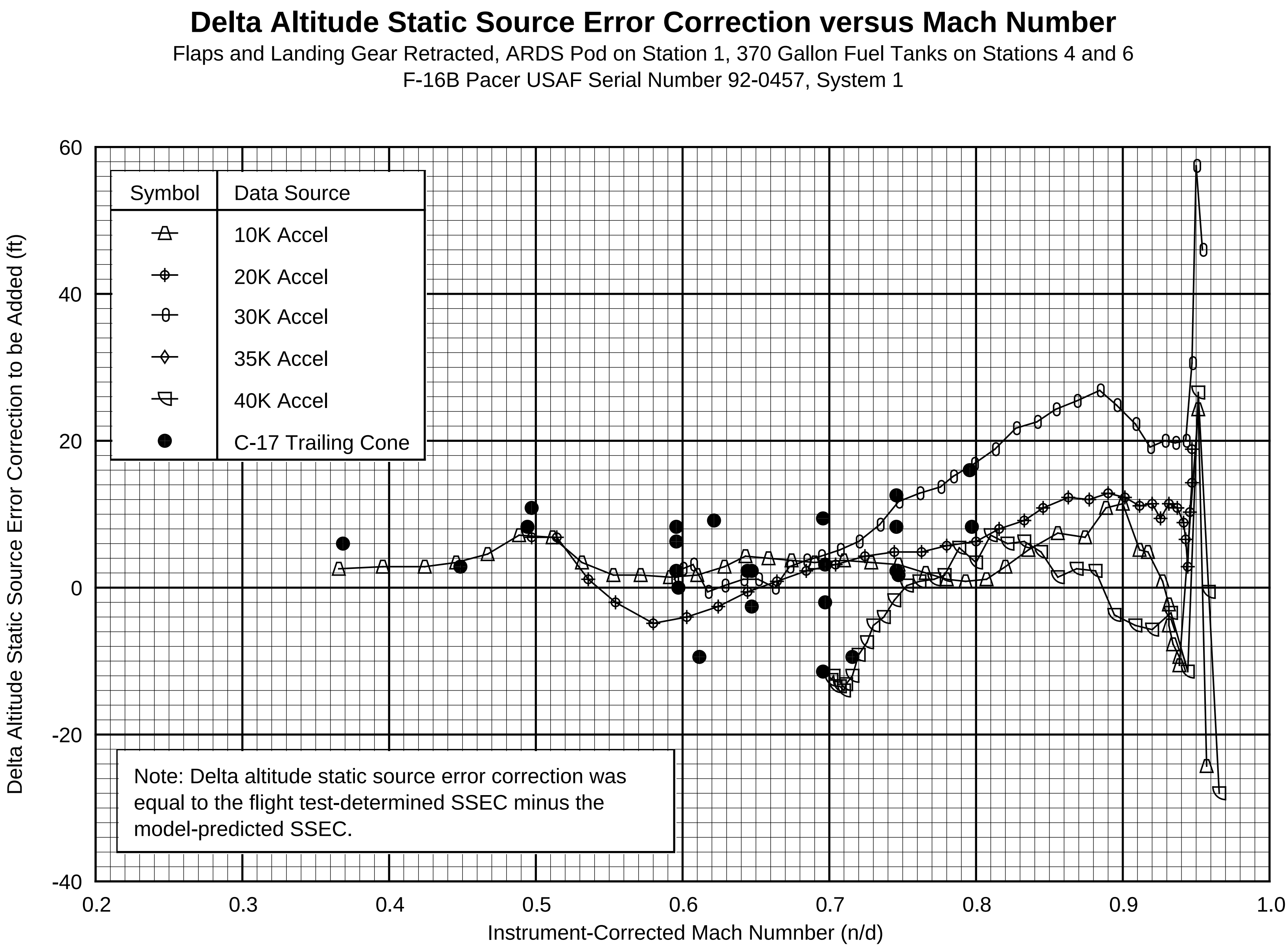

Figure C18 Comparison Between Flight Test Static Source Error Correction and Model - Altitude

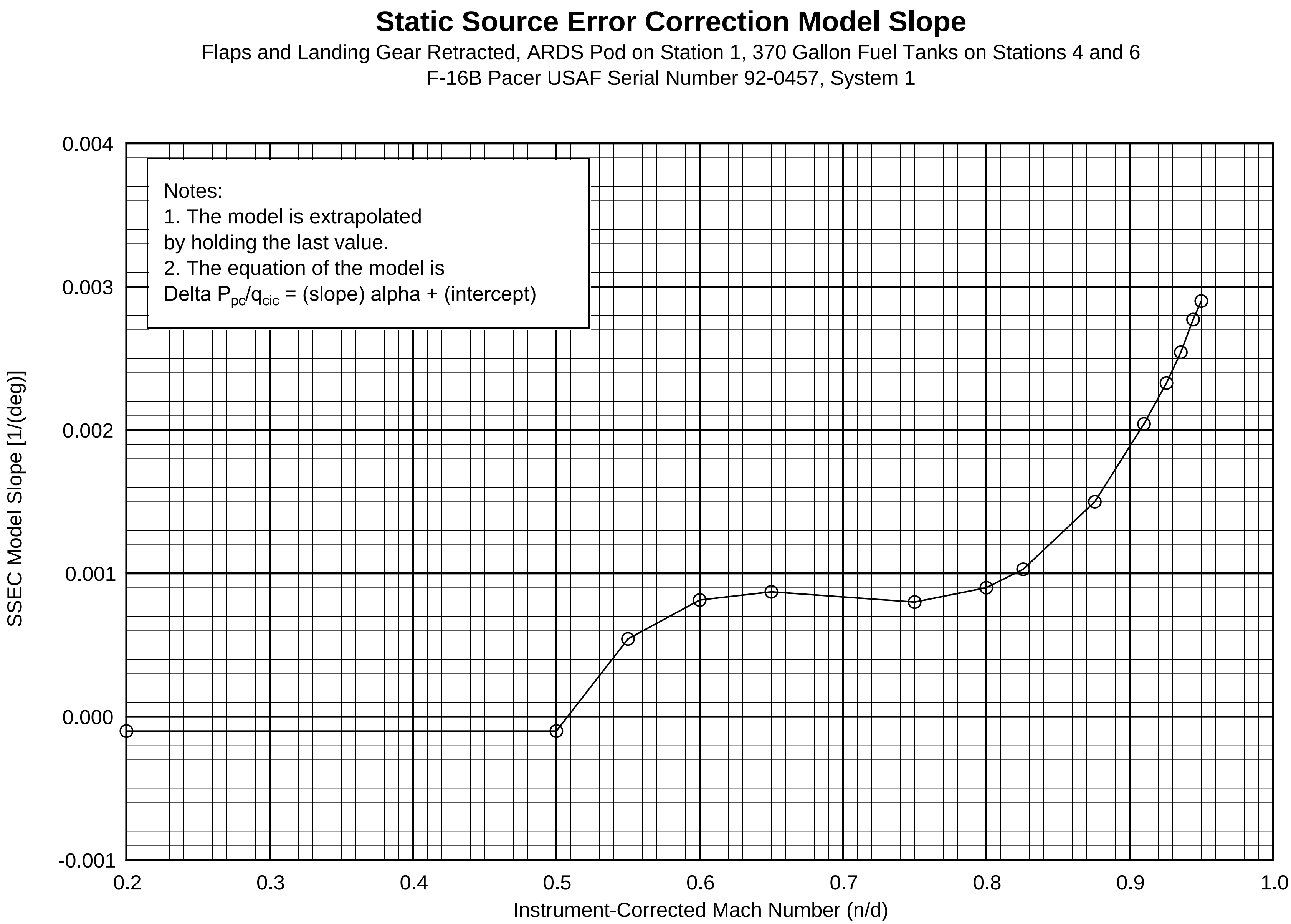

Figure C19 Static Source Error Correction Model Slope

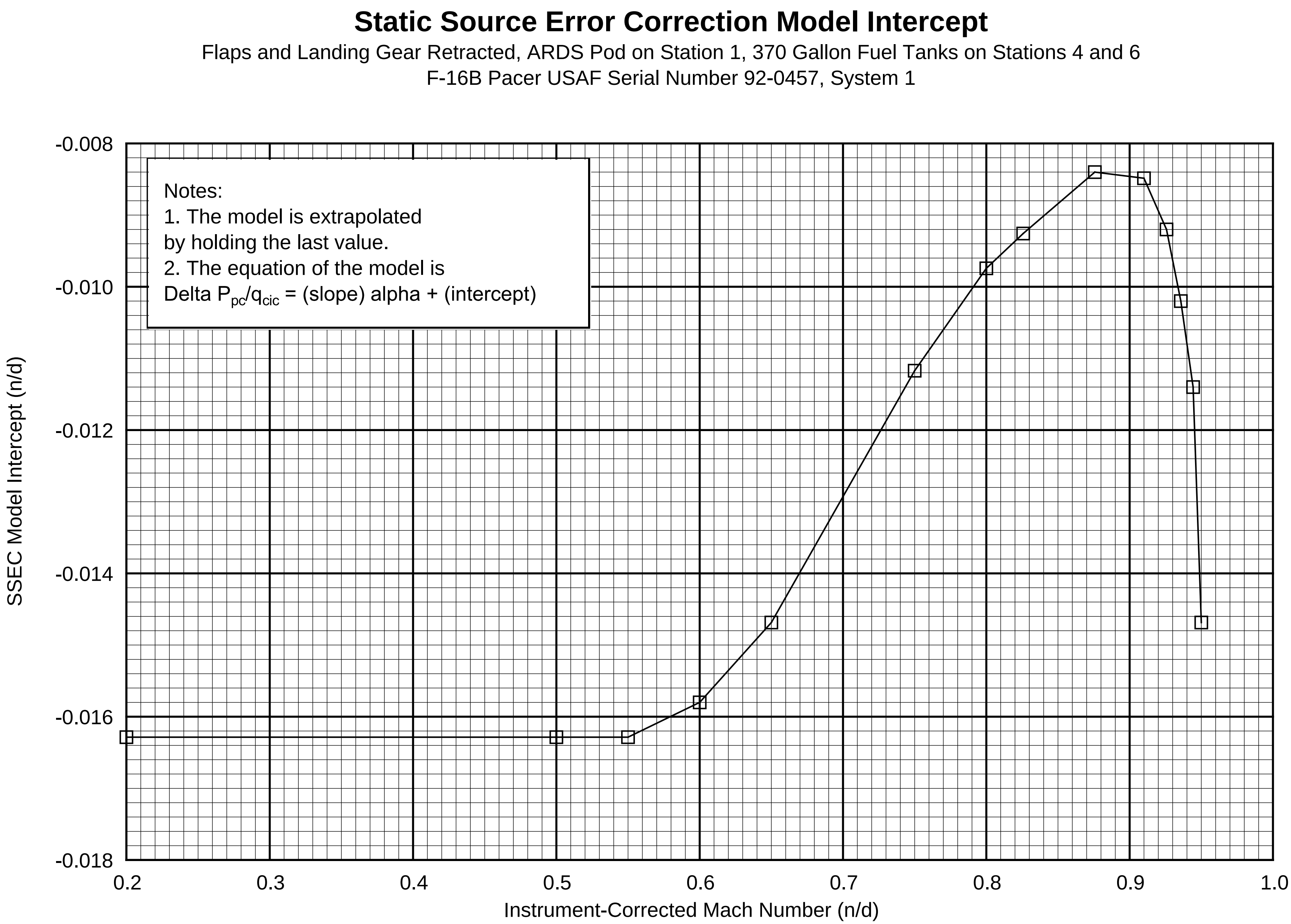

Figure C20 Static Source Error Correction Model Intercept

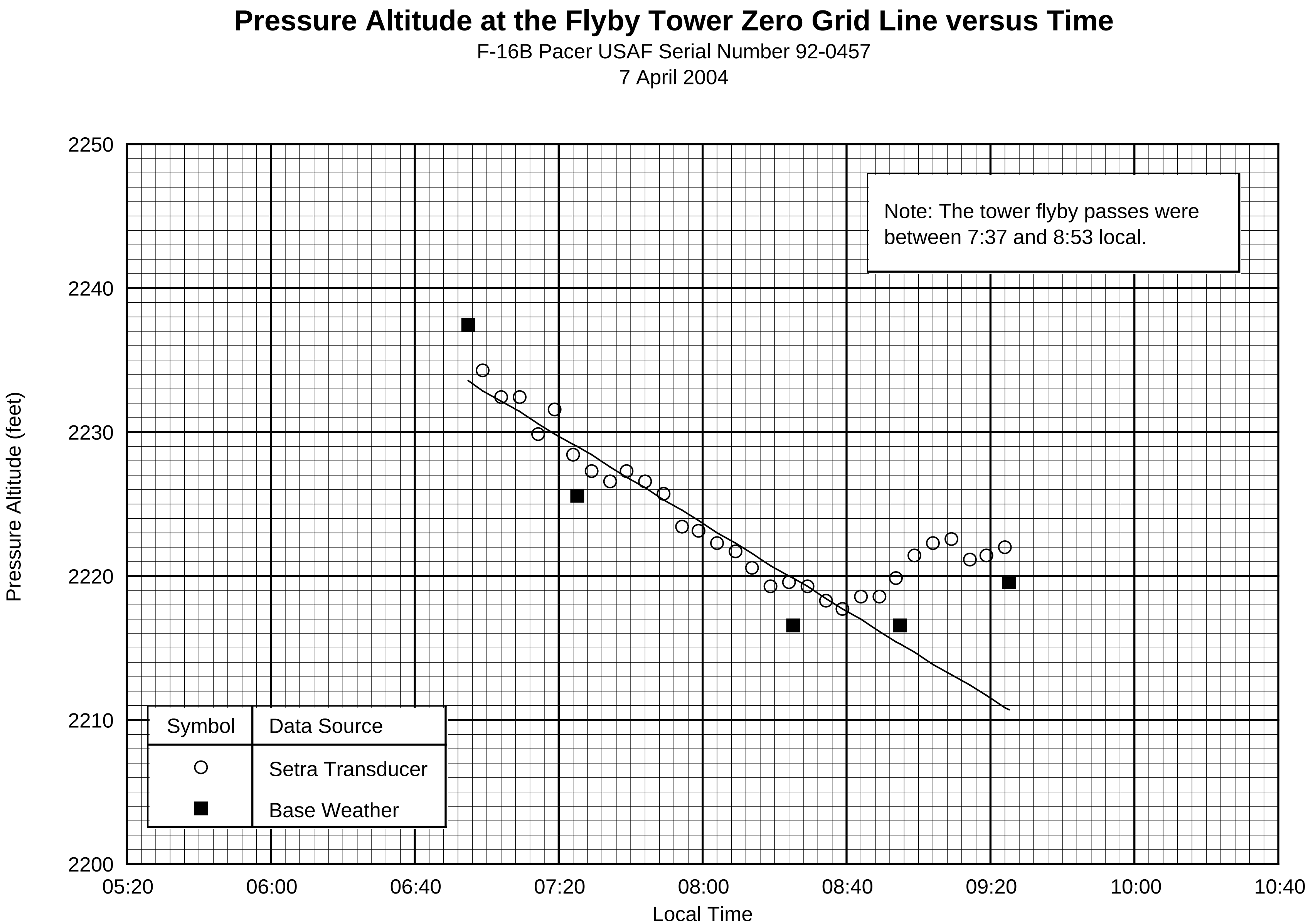

Figure C21 Pressure Altitude at the Zero Grid Line for the 7 April 2004 Tower Flybys

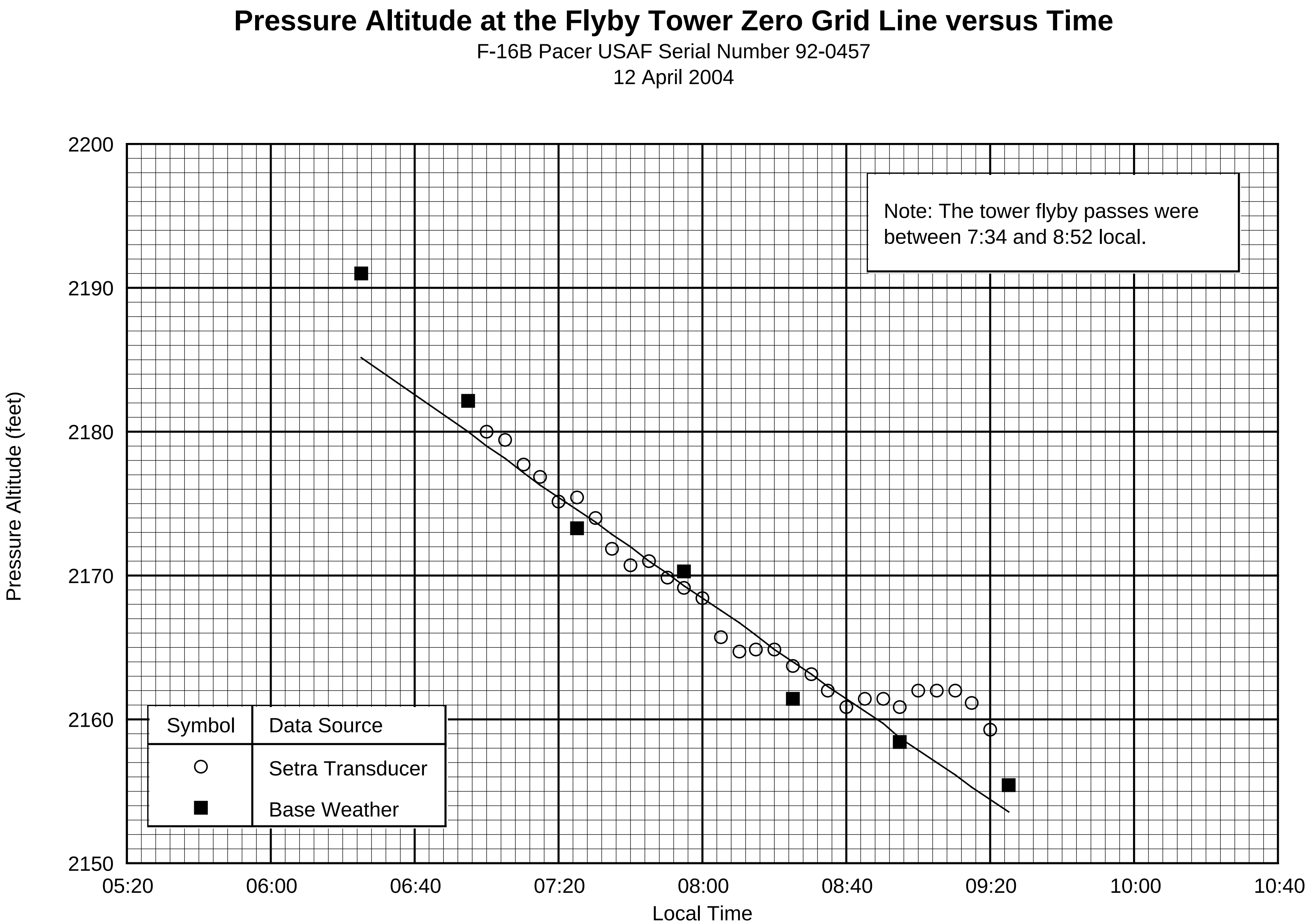

Figure C22 Pressure Altitude at the Zero Grid Line for the 12 April 2004 Tower Flybys

Pressure Altitude at the Flyby Tower Zero Grid Line versus Time

F-16B Pacer USAF Serial Number 92-0457

13 April 2004

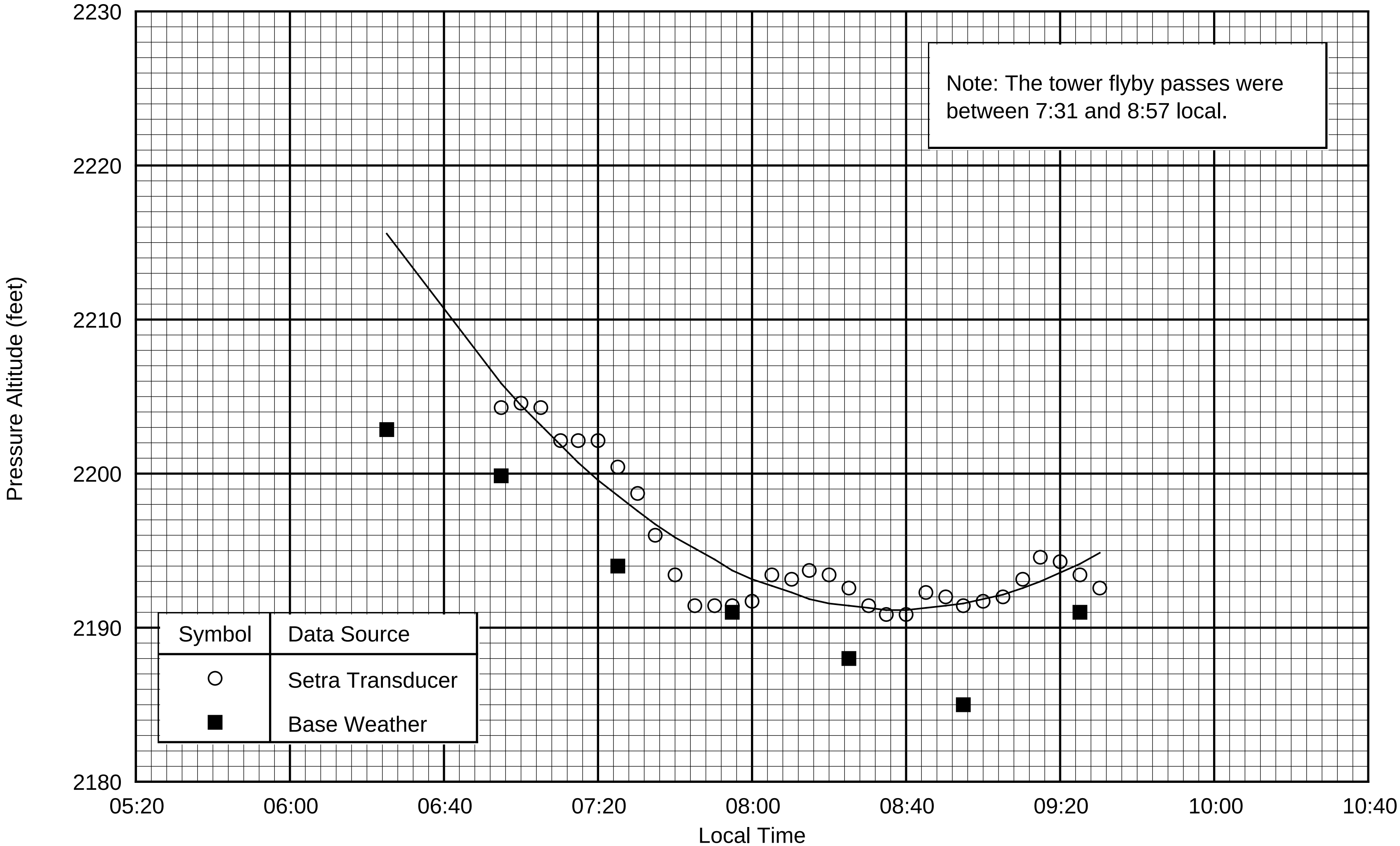

Figure C23 Pressure Altitude at the Zero Grid Line for the 13 April 2004 Tower Flybys

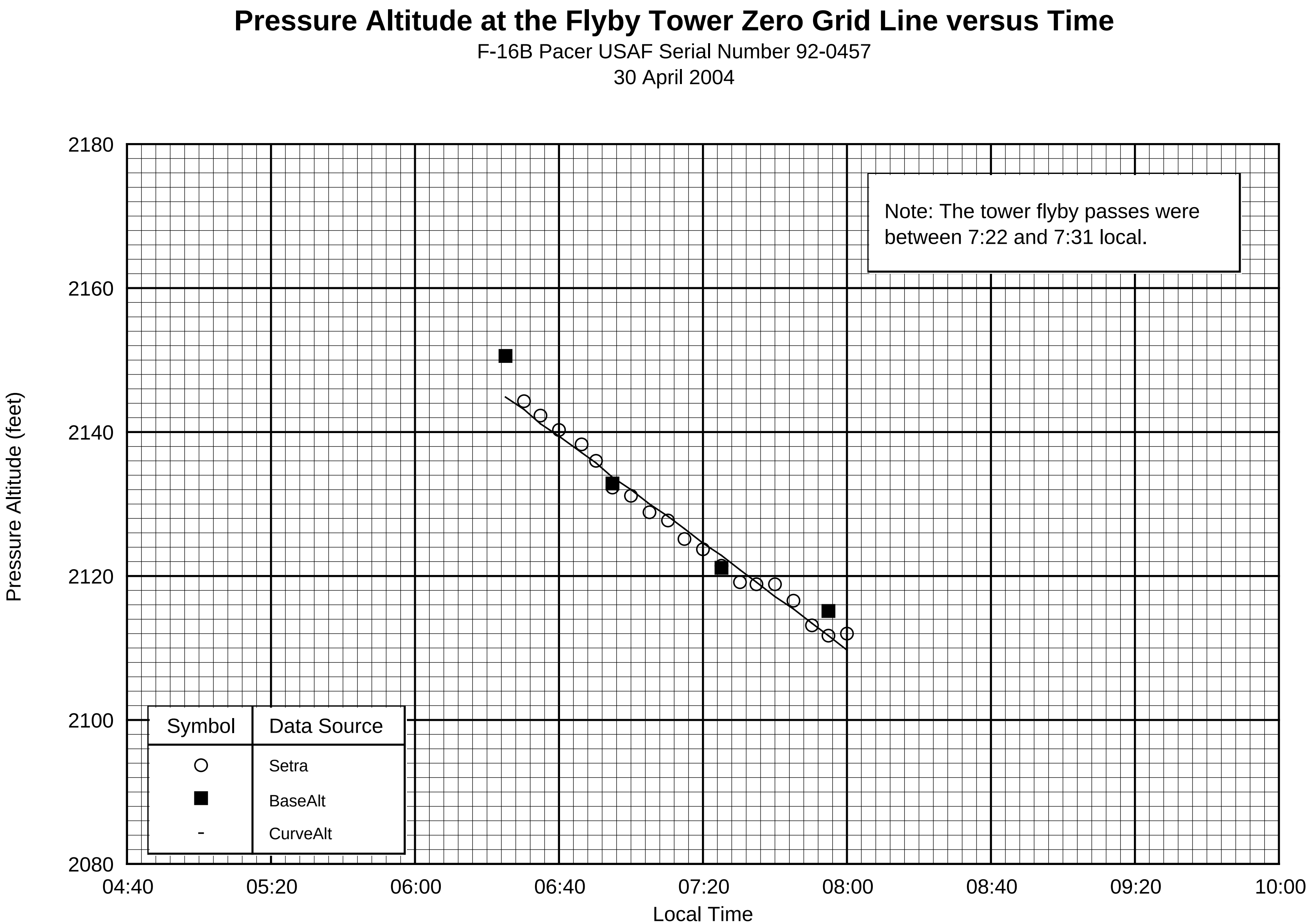

Figure C24 Pressure Altitude at the Zero Grid Line for the 30 April 2004 Tower Flybys

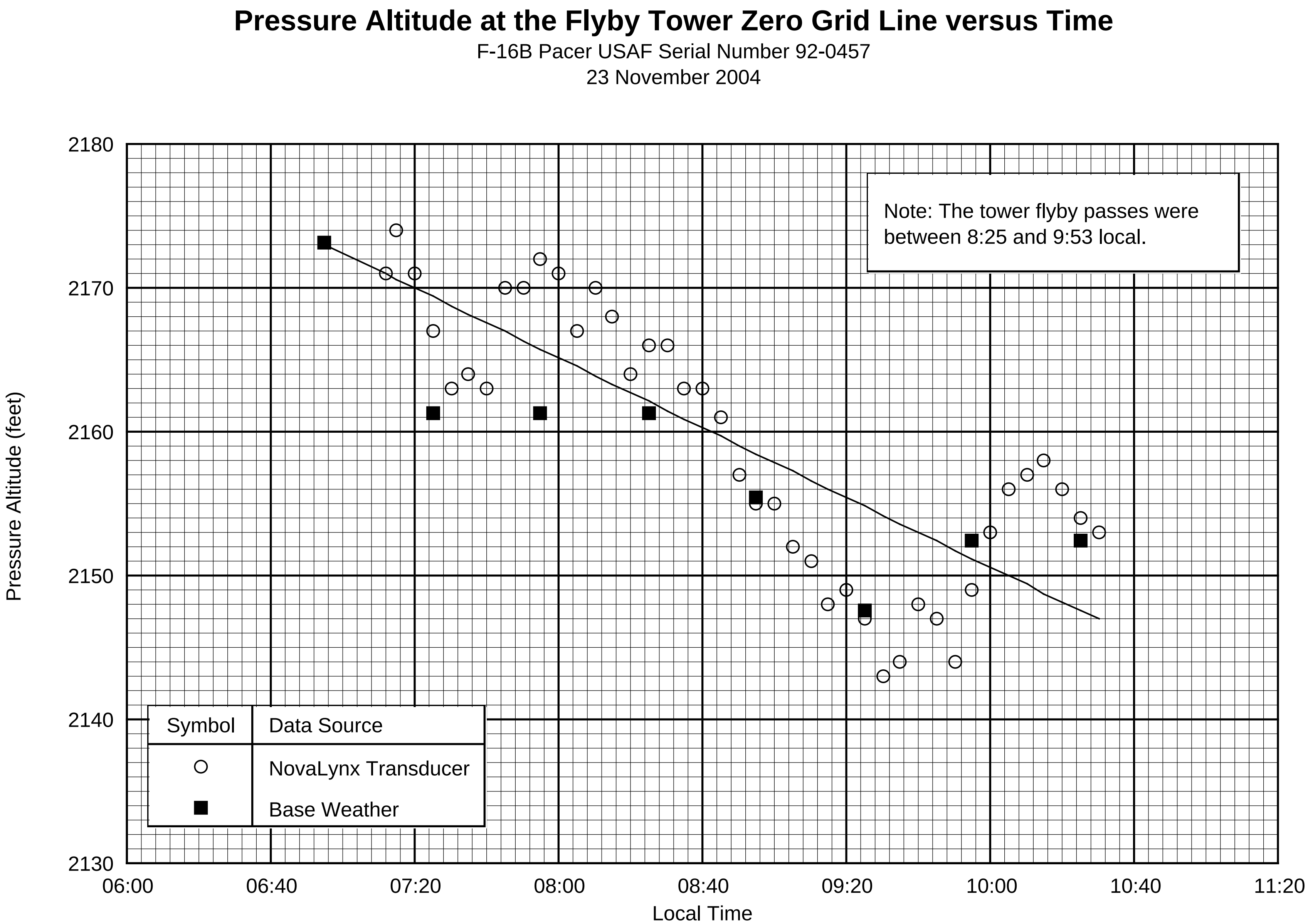

Figure C25 Pressure Altitude at the Zero Grid Line for the 23 November 2004 Tower Flybys

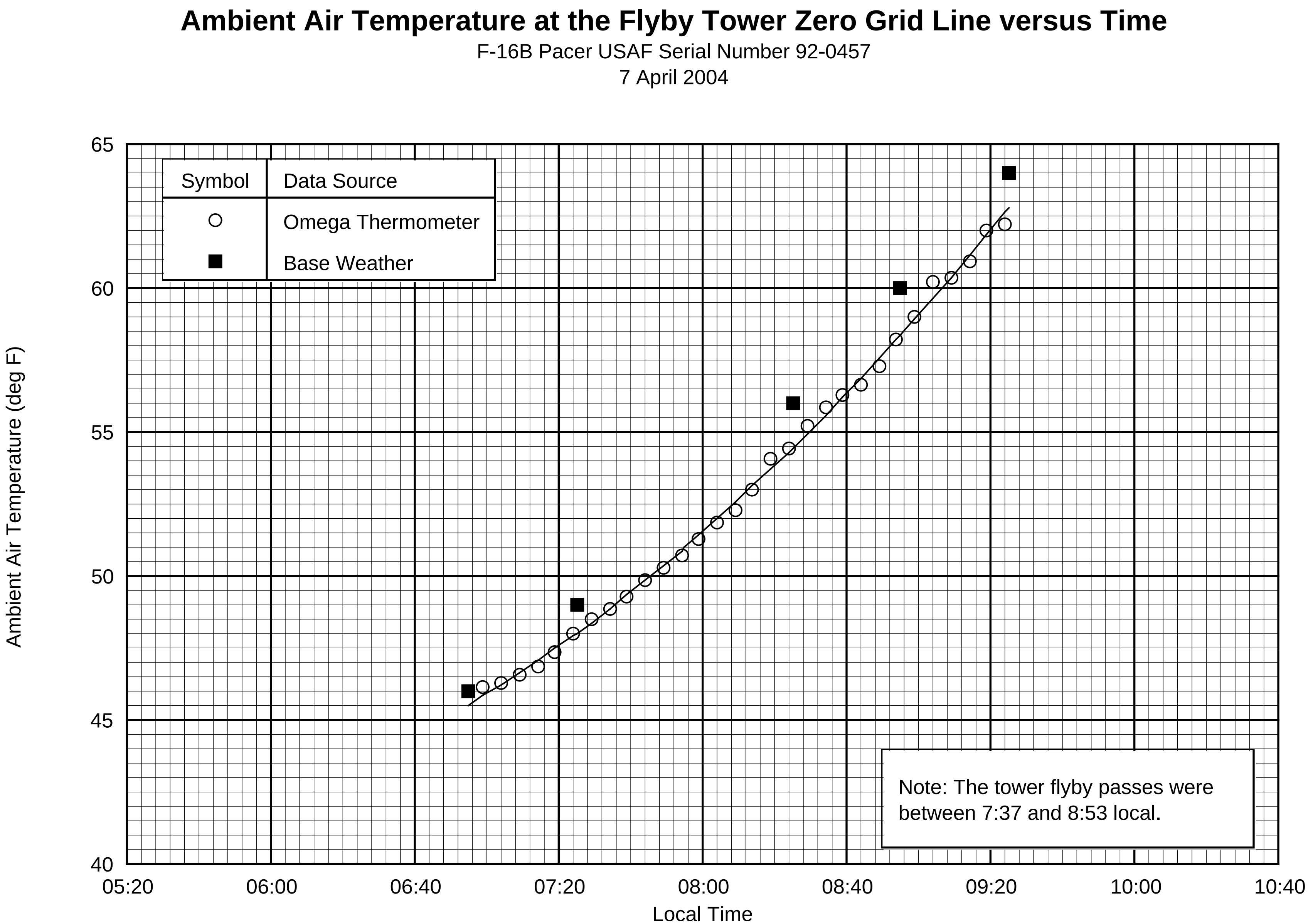

Figure C26 Ambient Air Temperature at the Zero Grid Line for the 7 April 2004 Tower Flybys

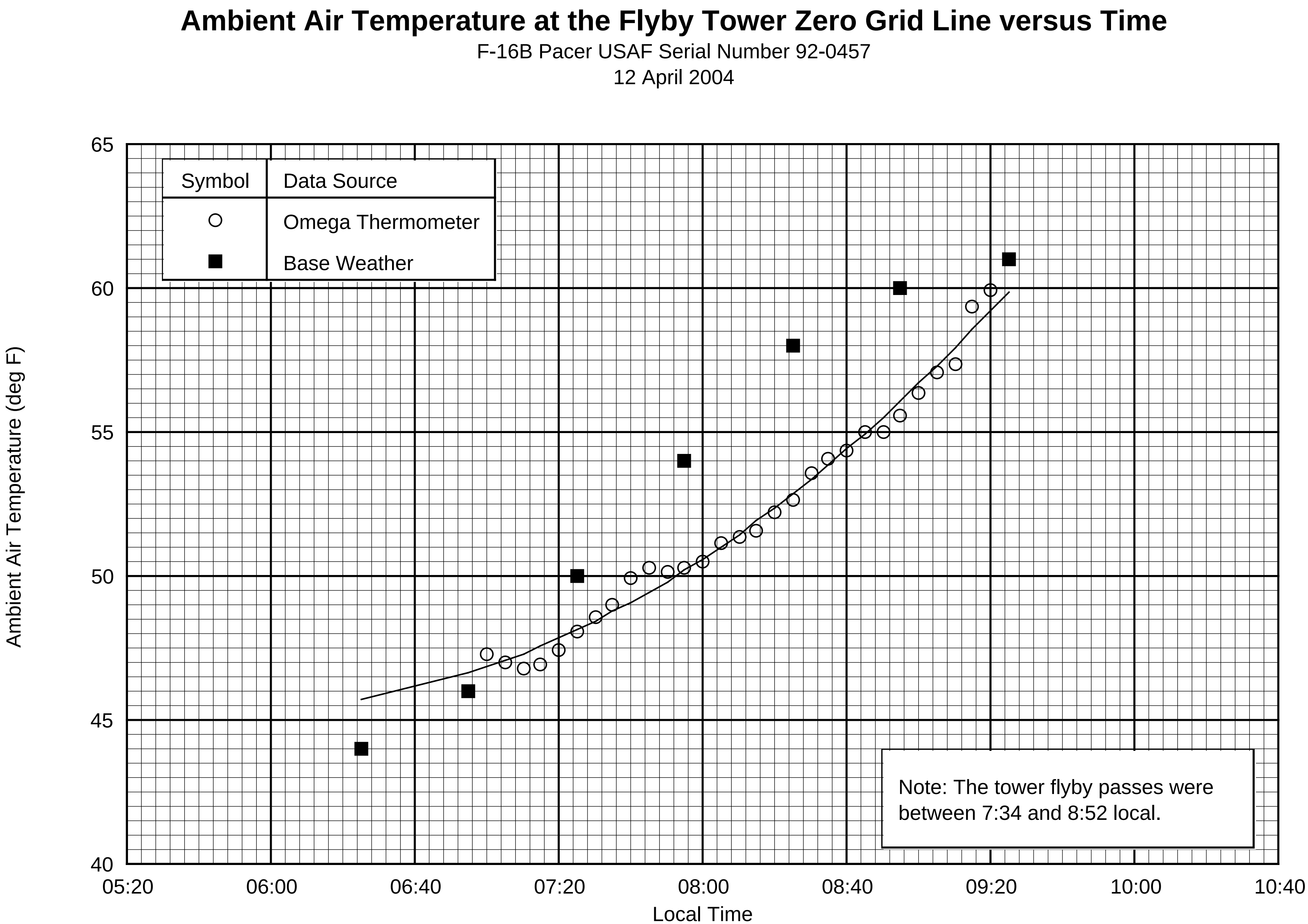

Figure C27 Ambient Air Temperature at the Zero Grid Line for the 12 April 2004 Tower Flybys

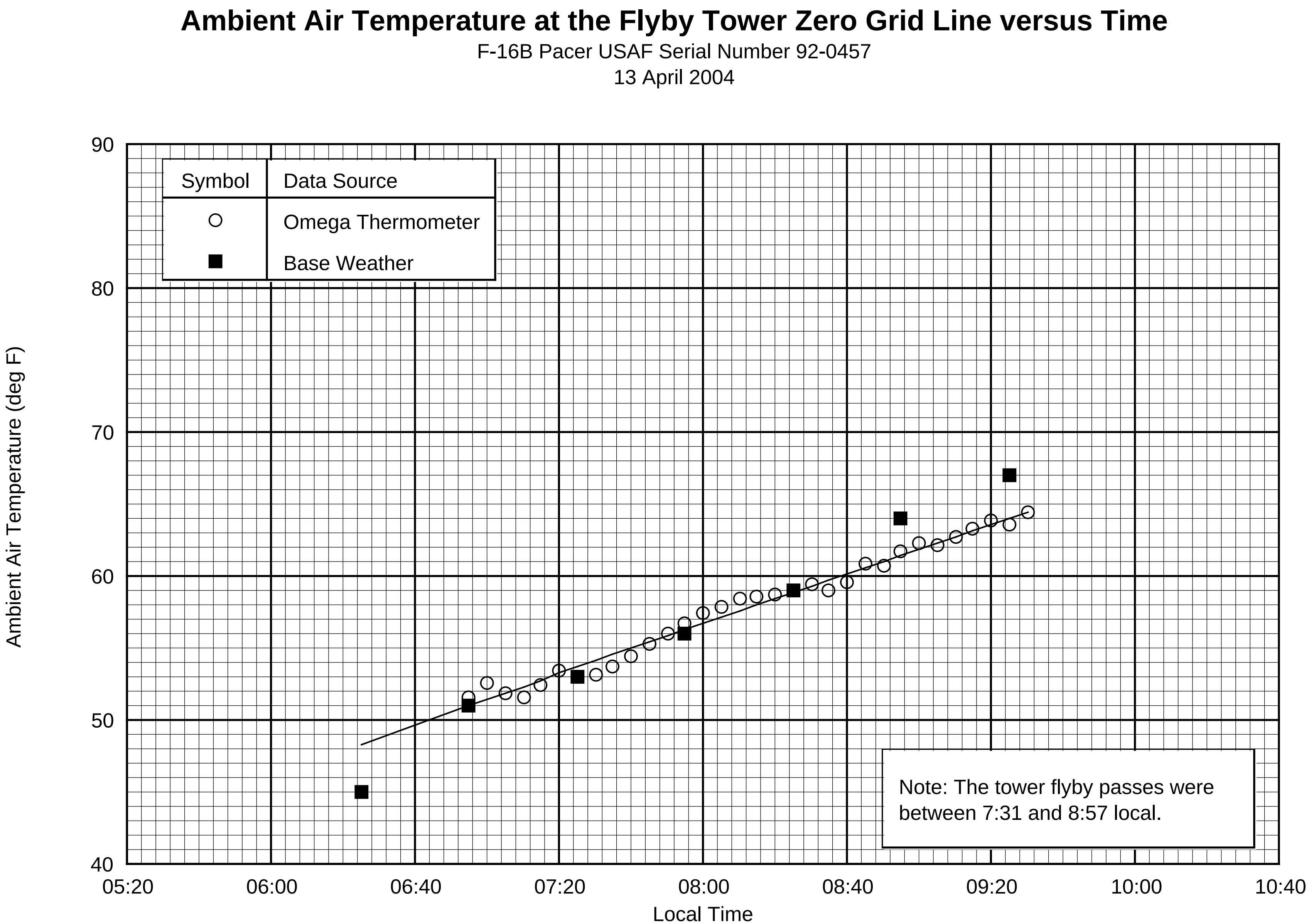

Figure 28 Ambient Air Temperature at the Zero Grid Line for the 13 April 2004 Tower Flybys

Ambient Air Temperature at the Flyby Tower Zero Grid Line versus Time

F-16B Pacer USAF Serial Number 92-0457

30 April 2004

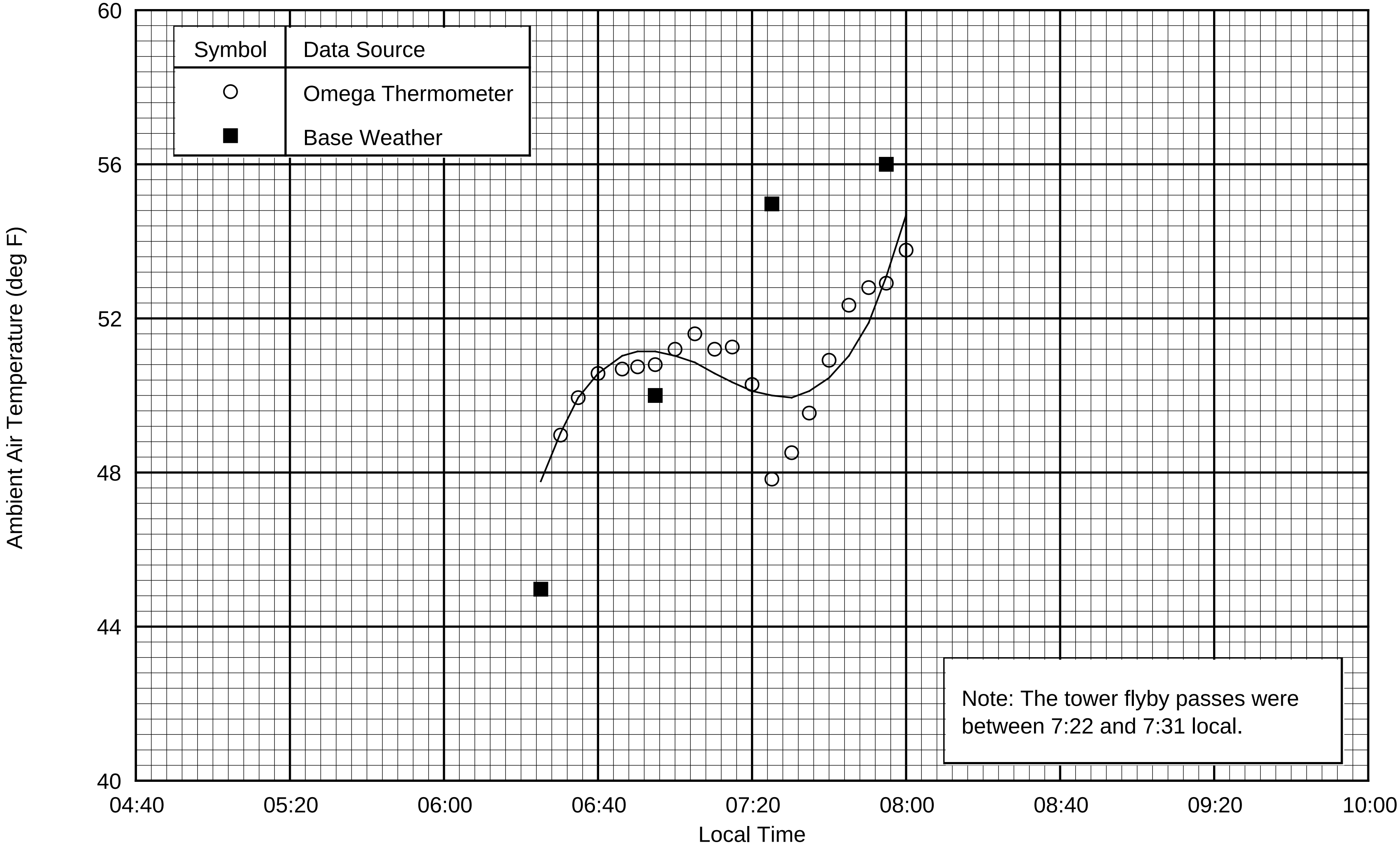

Figure C29 Ambient Air Temperature at the Zero Grid Line for the 30 April 2004 Tower Flybys

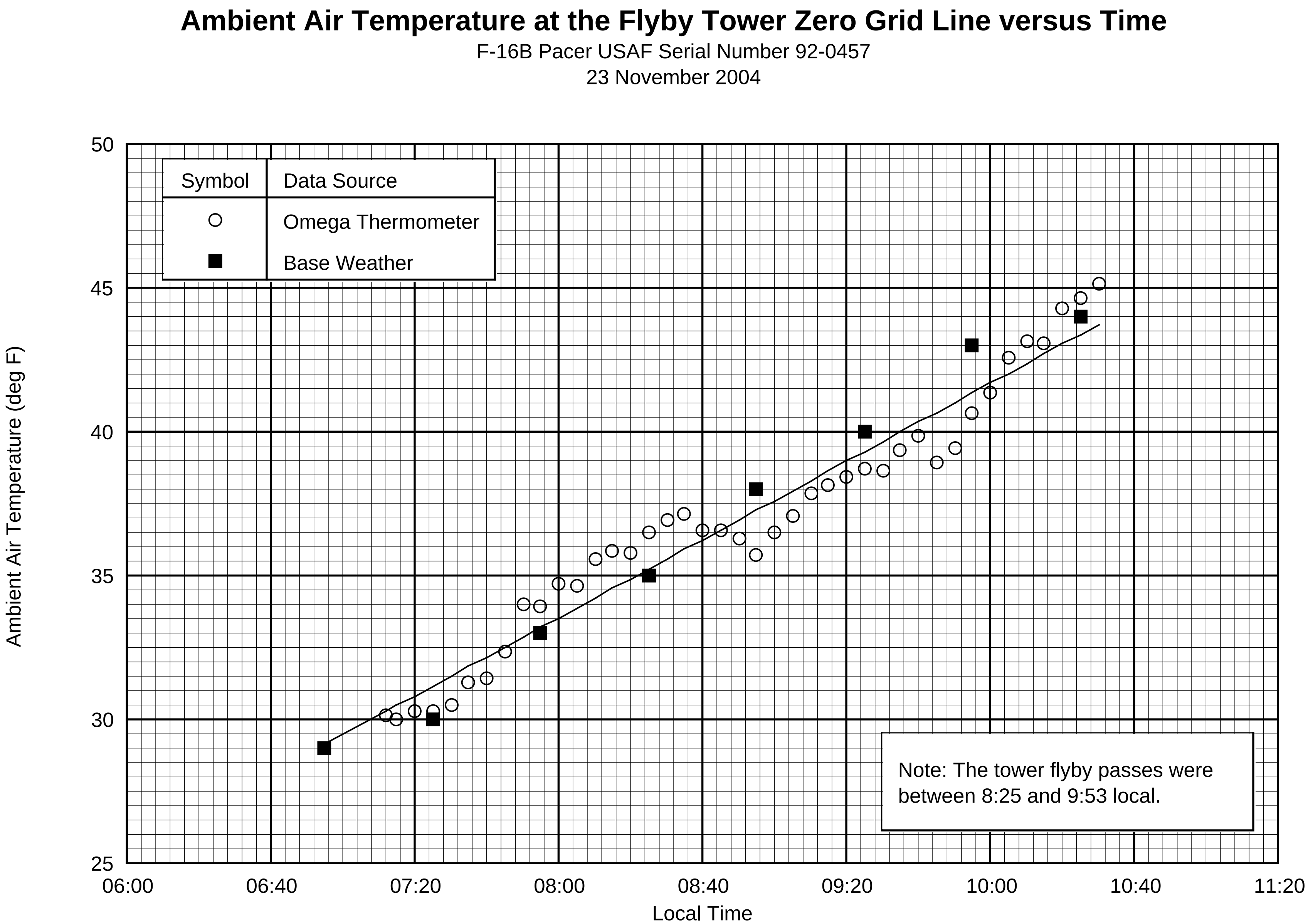

Figure C30 Ambient Air Temperature at the Zero Grid Line for the 23 November 2004 Tower Flybys

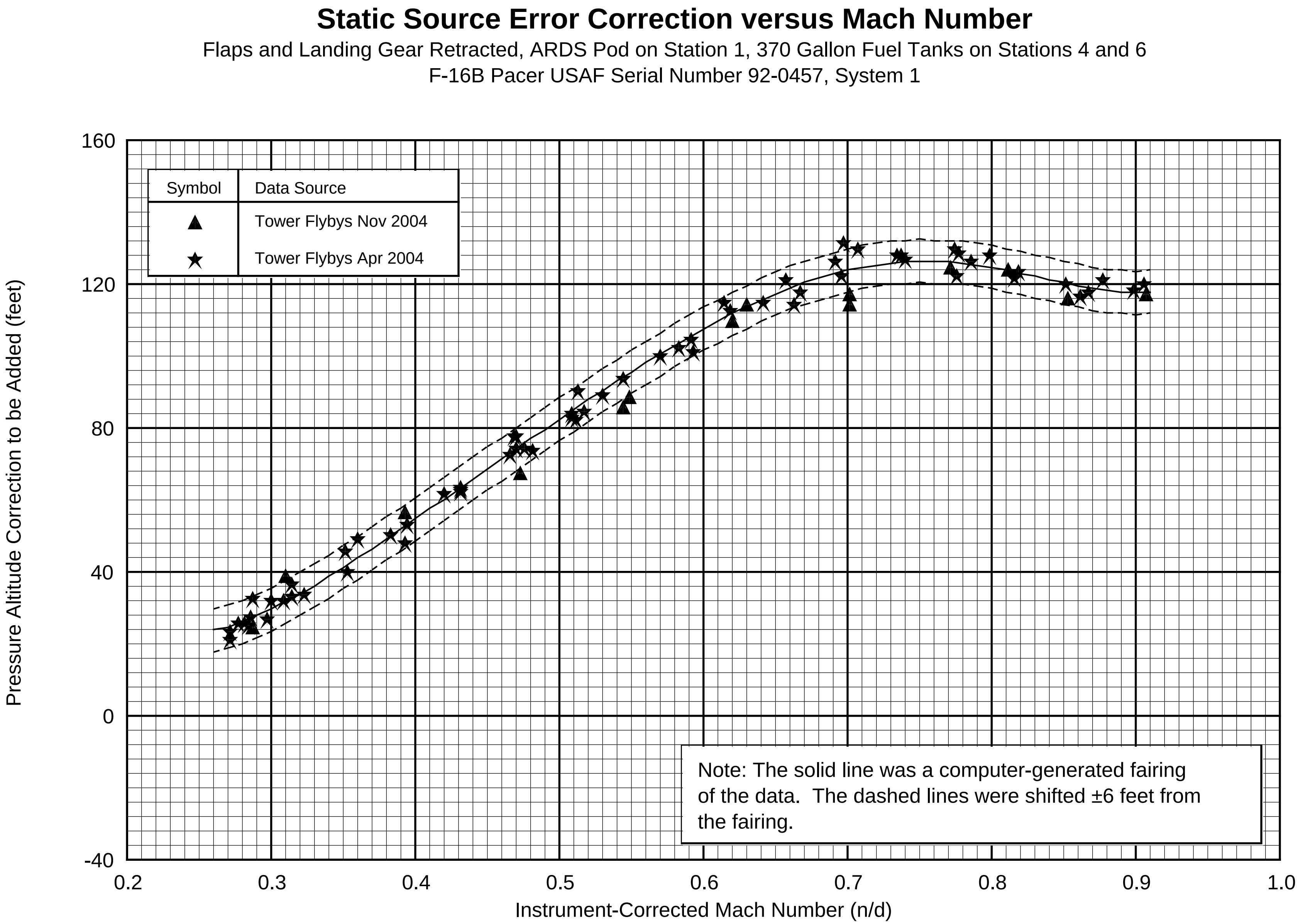

Figure C31 Altitude Static Source Error Correction versus Mach Number from the Tower Flybys

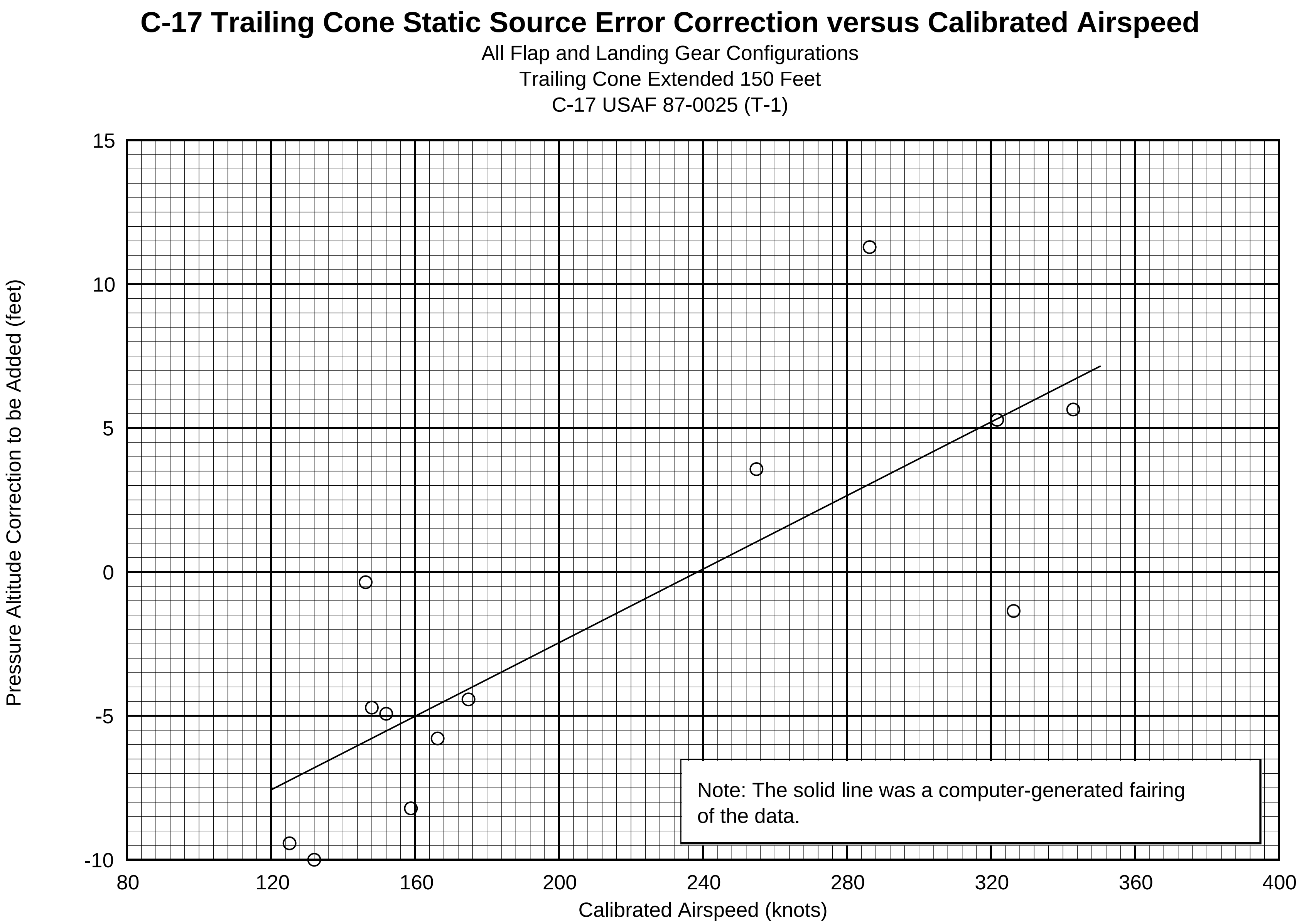

Figure C32 C-17 Trailing Cone Altitude Static Source Error Corrections from the Tower Flybys

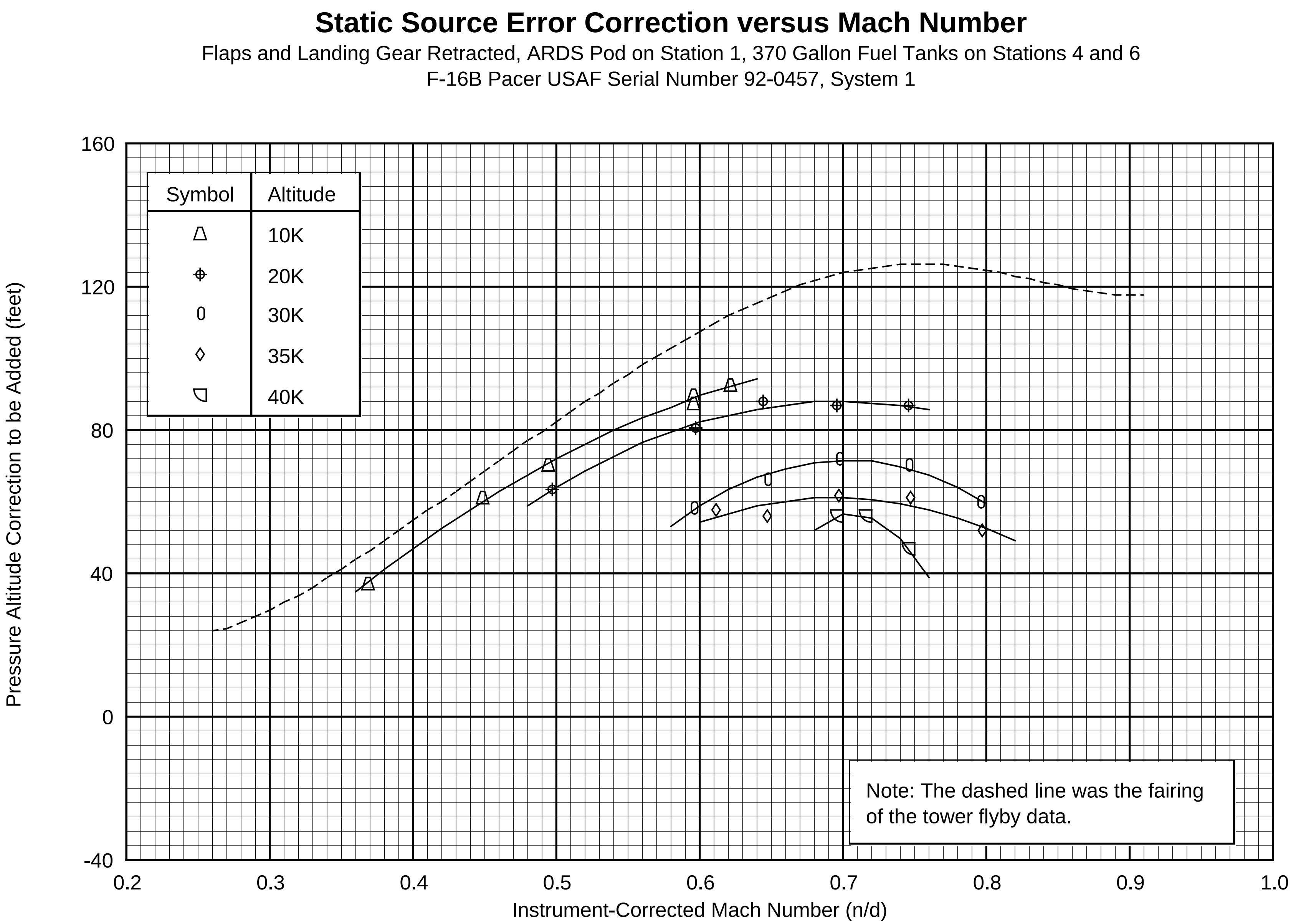

Figure C33 Altitude Static Source Error Correction versus Mach Number from the Formation Flight with the C-17 Trailing Cone

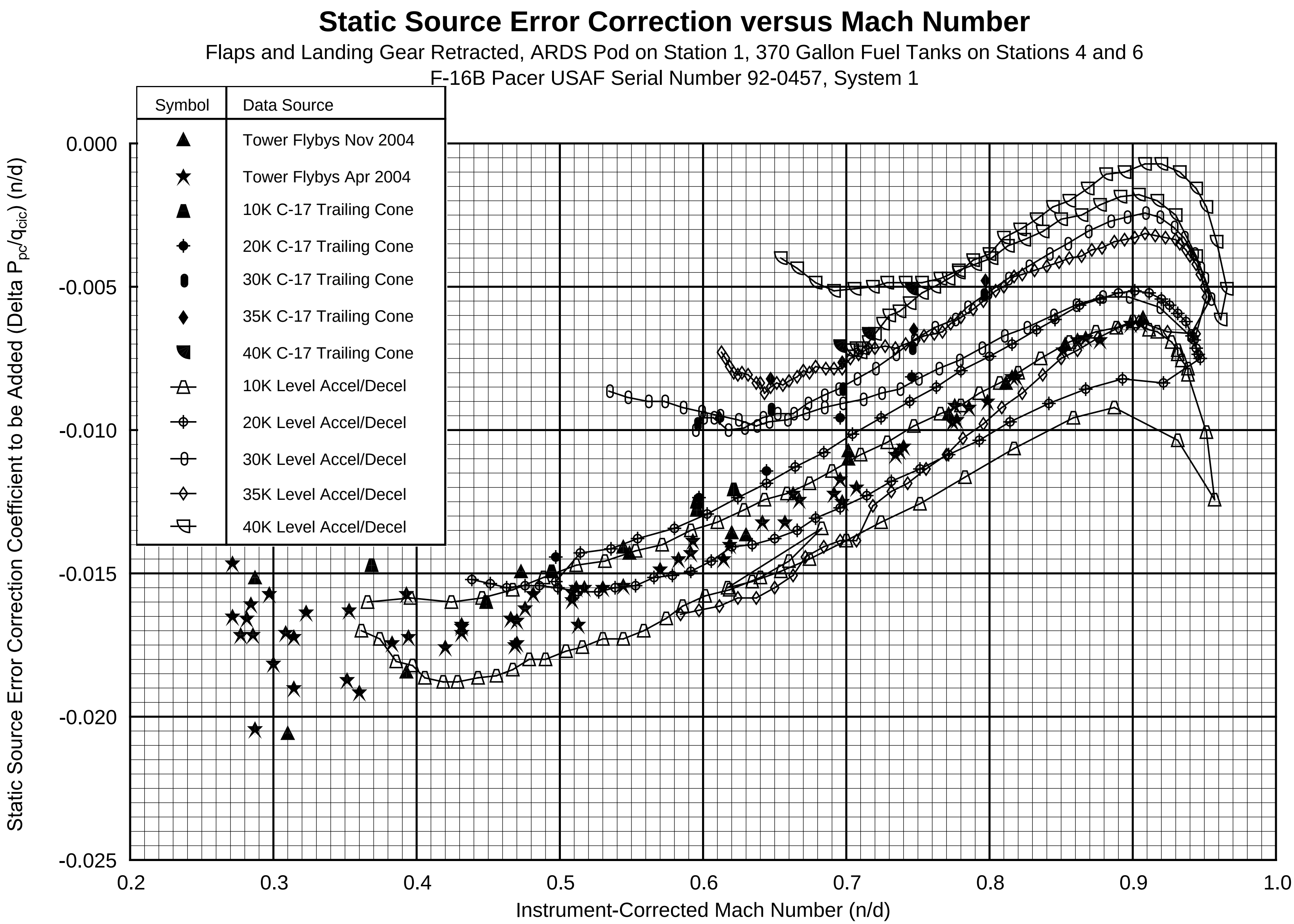

Figure C34 Static Source Error Correction versus Mach Number - All Data

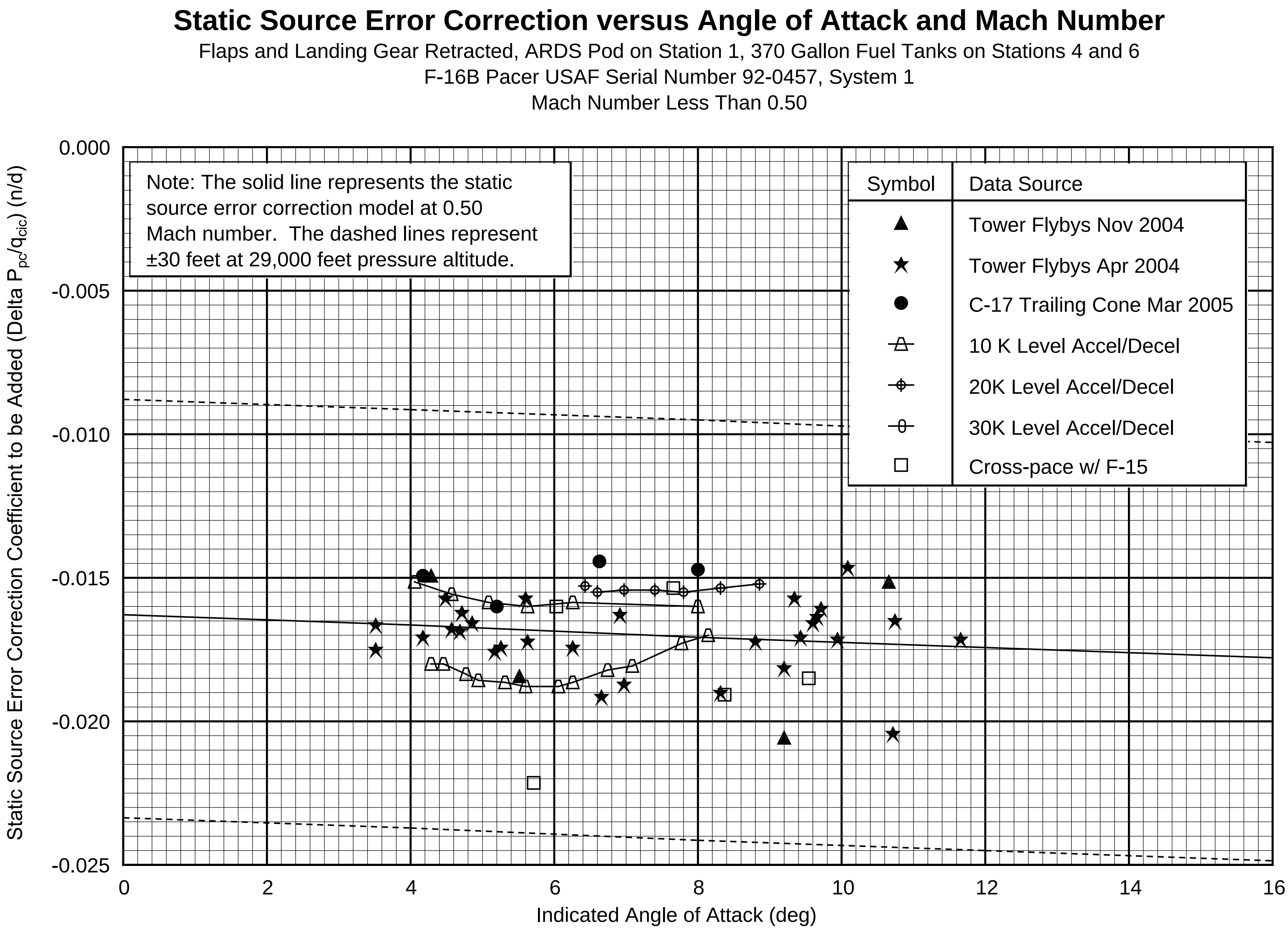

Figure C35 Static Source Error Corrections for Mach Numbers Less Than 0.50 - All Data

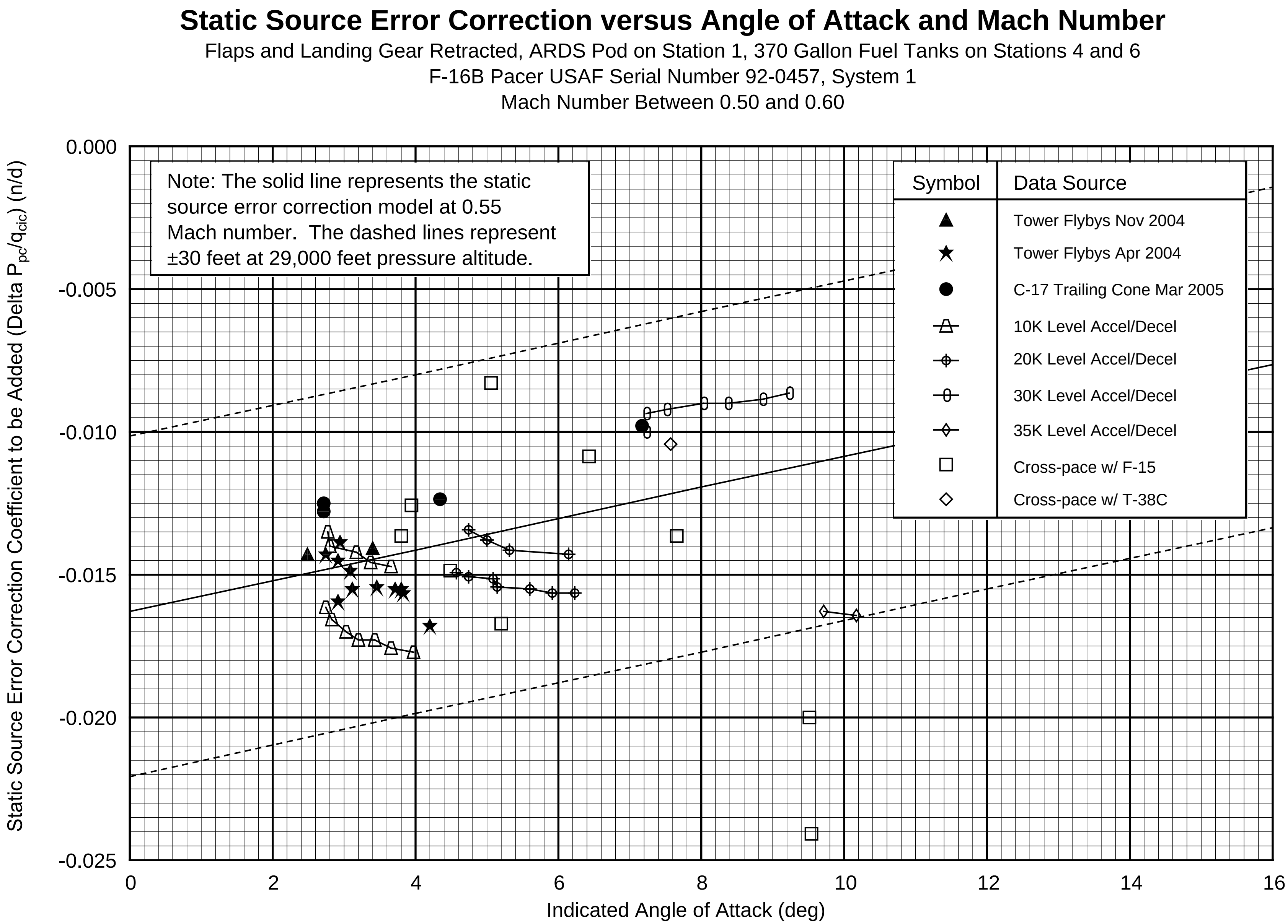

Figure C36 Static Source Error Corrections for Mach Numbers Between 0.50 and 0.60 - All Data

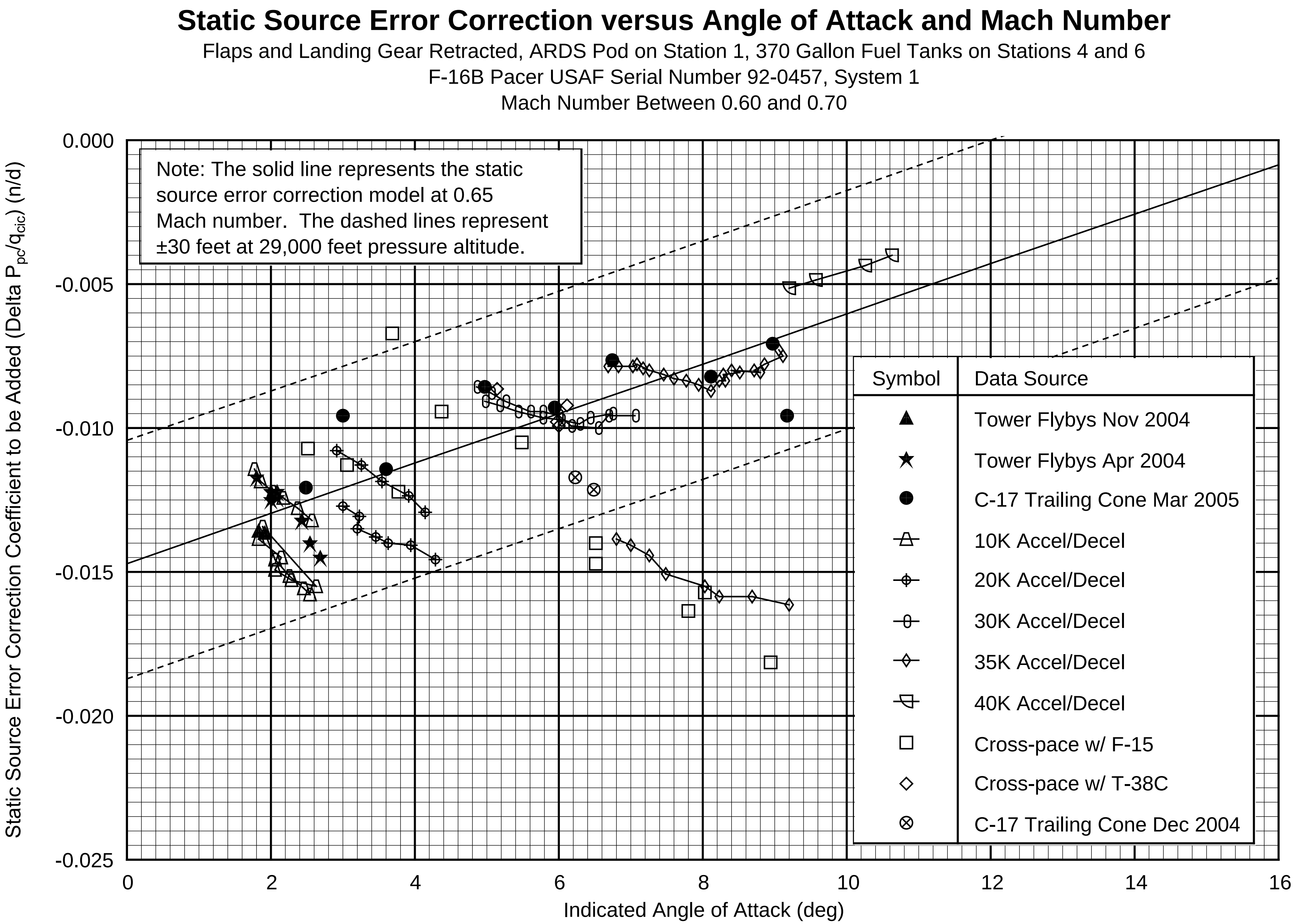

Figure C37 Static Source Error Corrections for Mach Numbers Between 0.60 and 0.70 - All Data

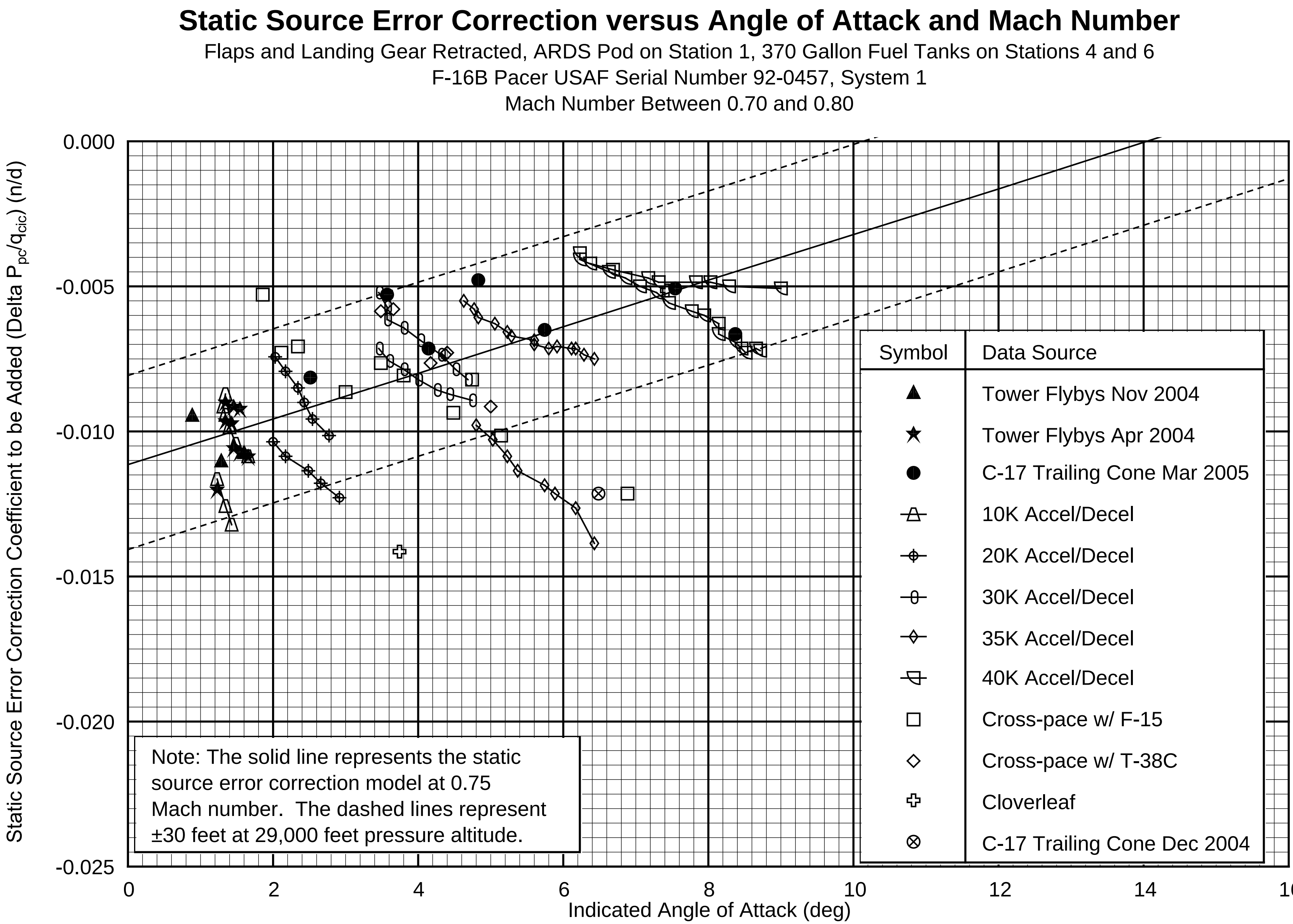

Figure C38 Static Source Error Corrections for Mach Numbers Between 0.70 and 0.80 - All Data

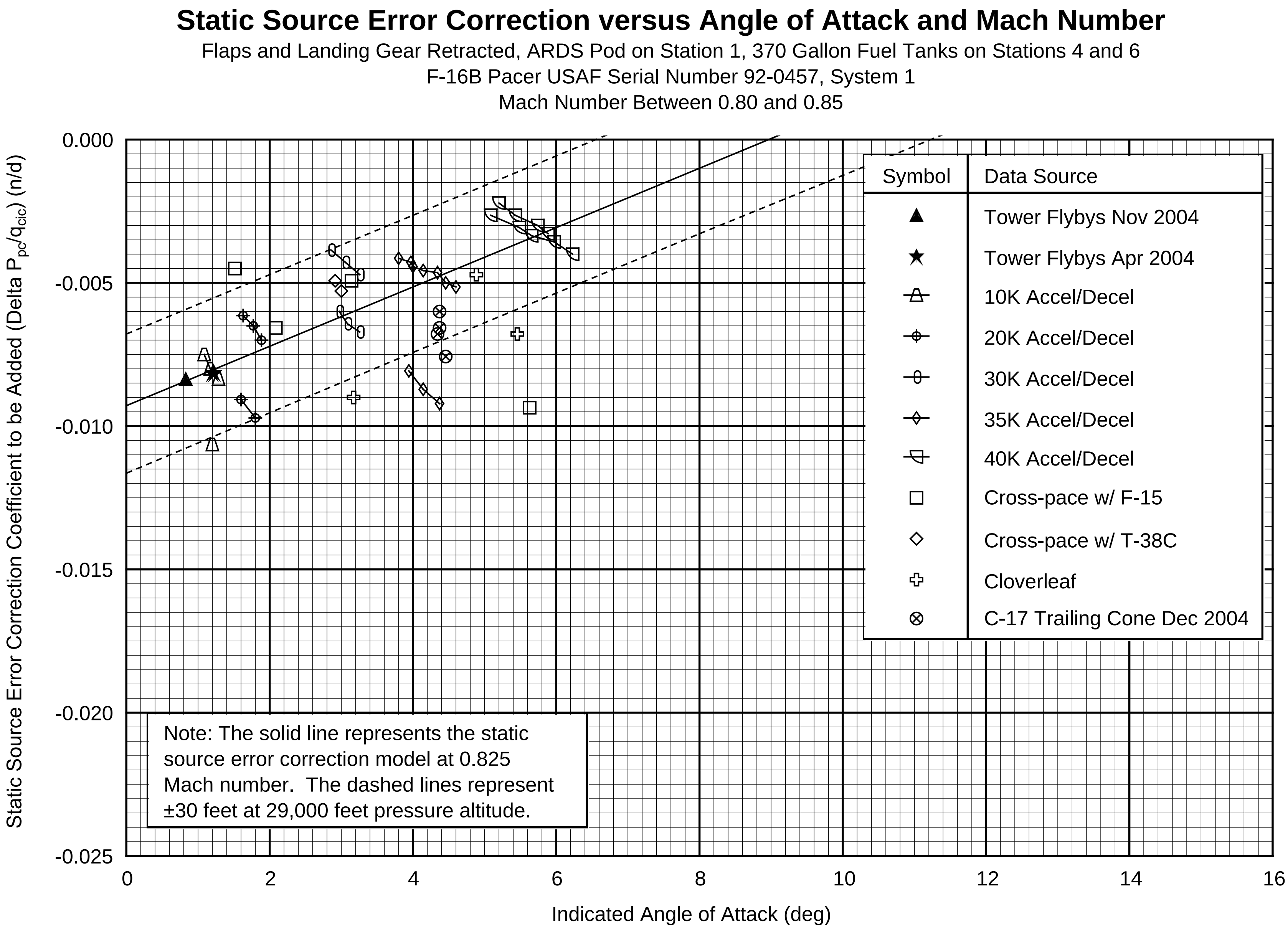

Figure C39 Static Source Error Corrections for Mach Numbers Between 0.80 and 0.85 - All Data

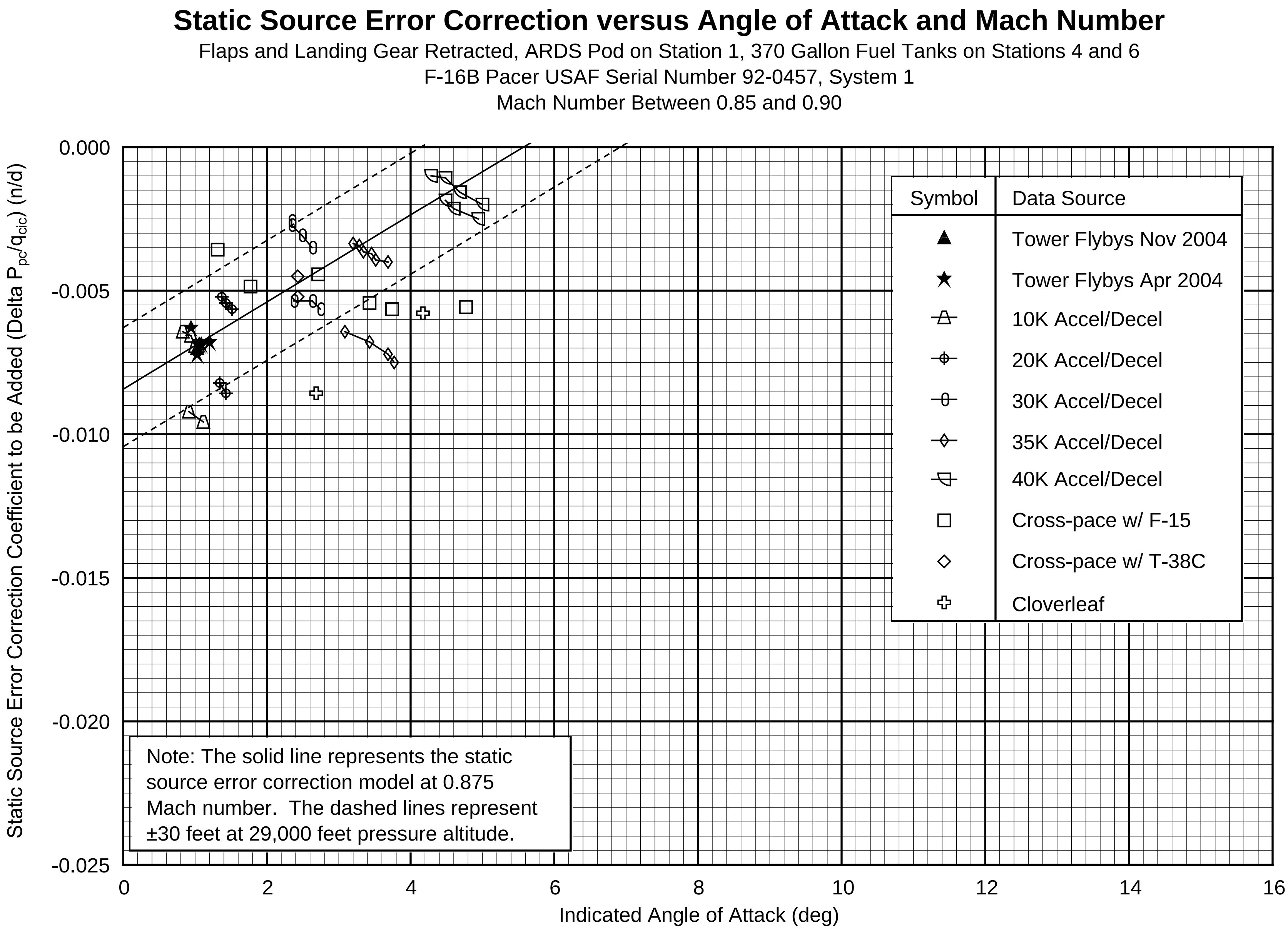

Figure C40 Static Source Error Corrections for Mach Numbers Between 0.85 and 0.90 - All Data

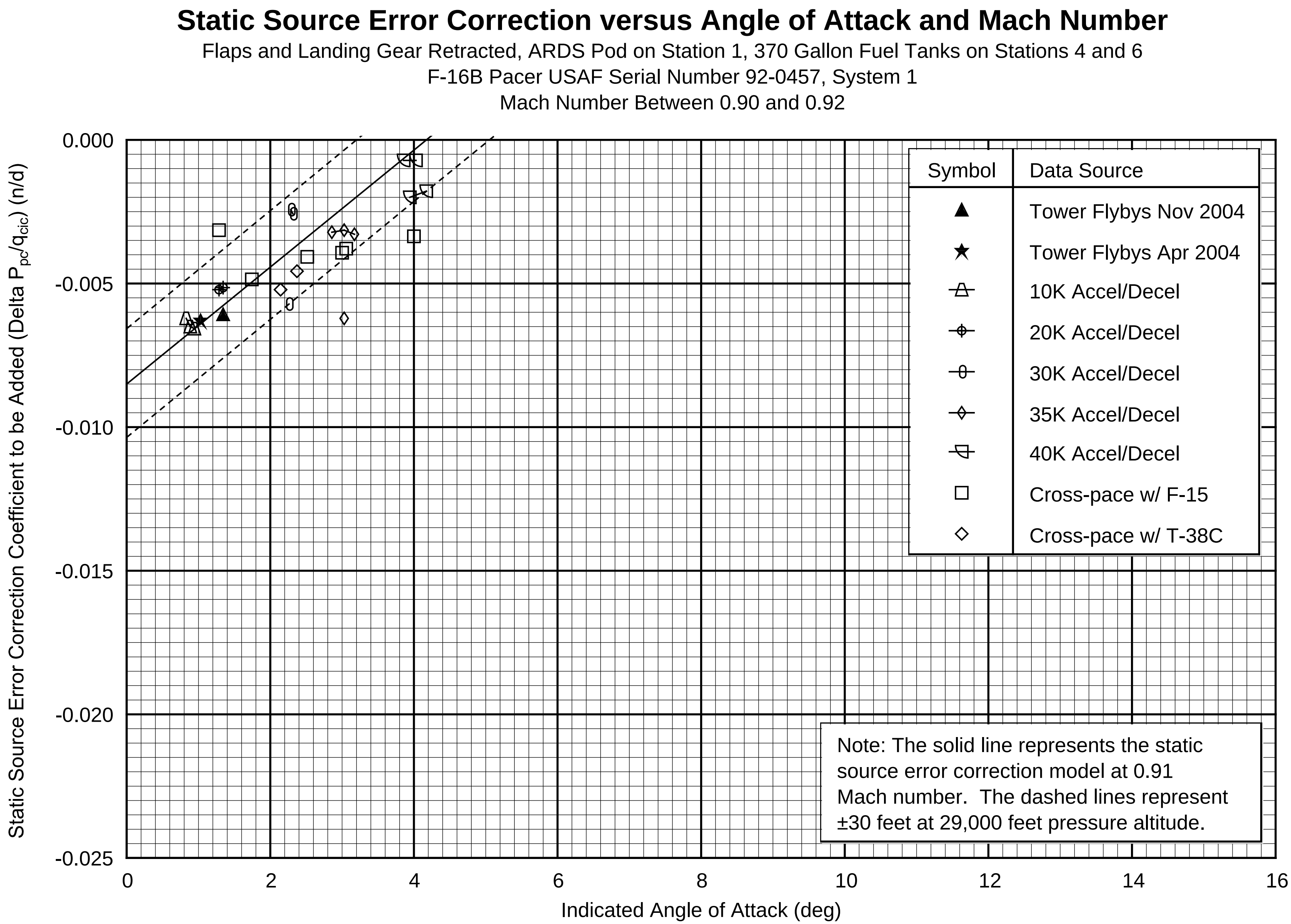

Figure C41 Static Source Error Corrections for Mach Numbers between 0.90 and 0.92 - All Data

Static Source Error Correction versus Angle of Attack and Mach Number

Flaps and Landing Gear Retracted, ARDS Pod on Station 1, 370 Gallon Fuel Tanks on Stations 4 and 6
F-16B Pacer USAF Serial Number 92-0457, System 1
Mach Number Between 0.92 and 0.93

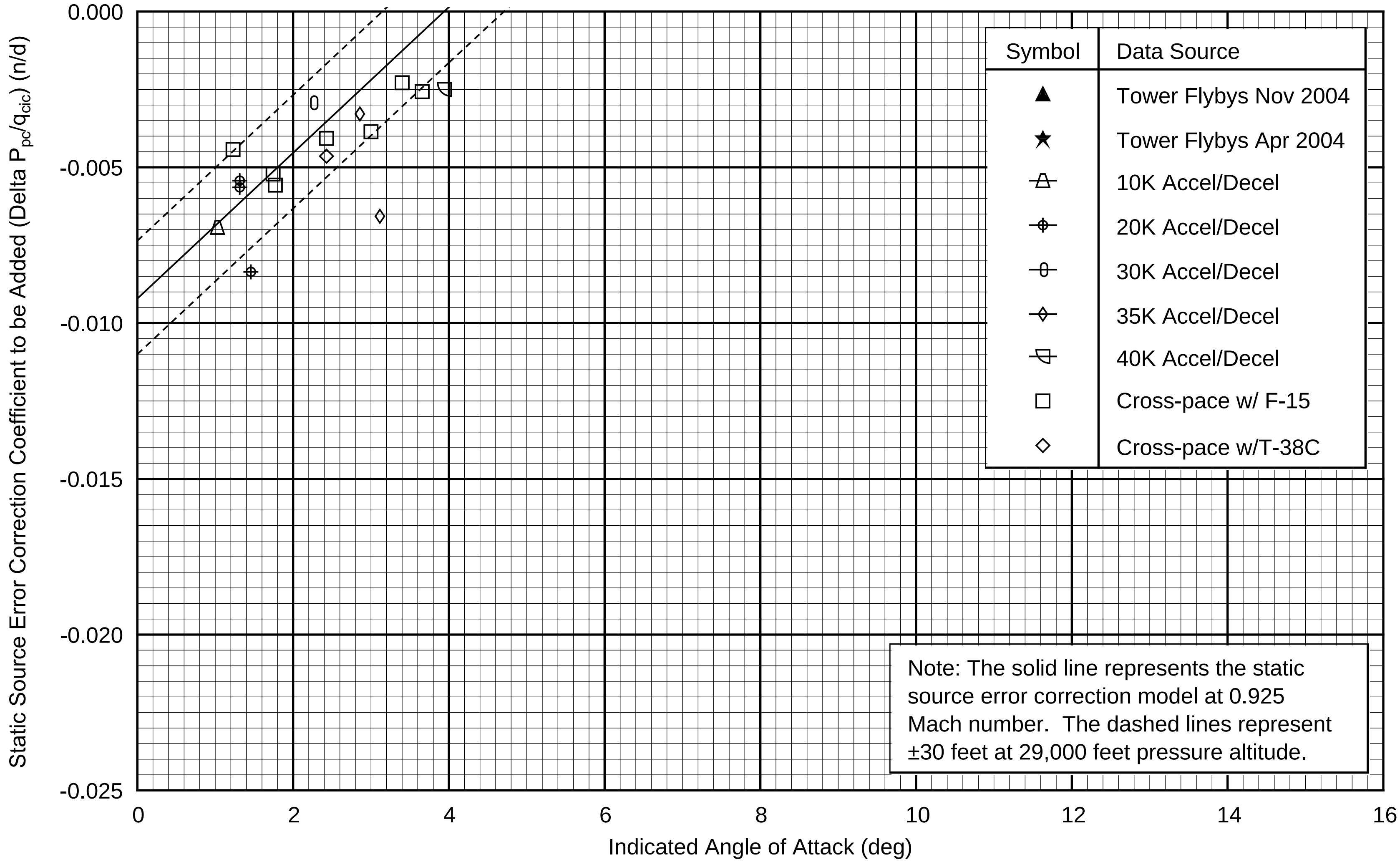

Figure C42 Static Source Error Corrections for Mach Numbers between 0.92 and 0.93 - All Data

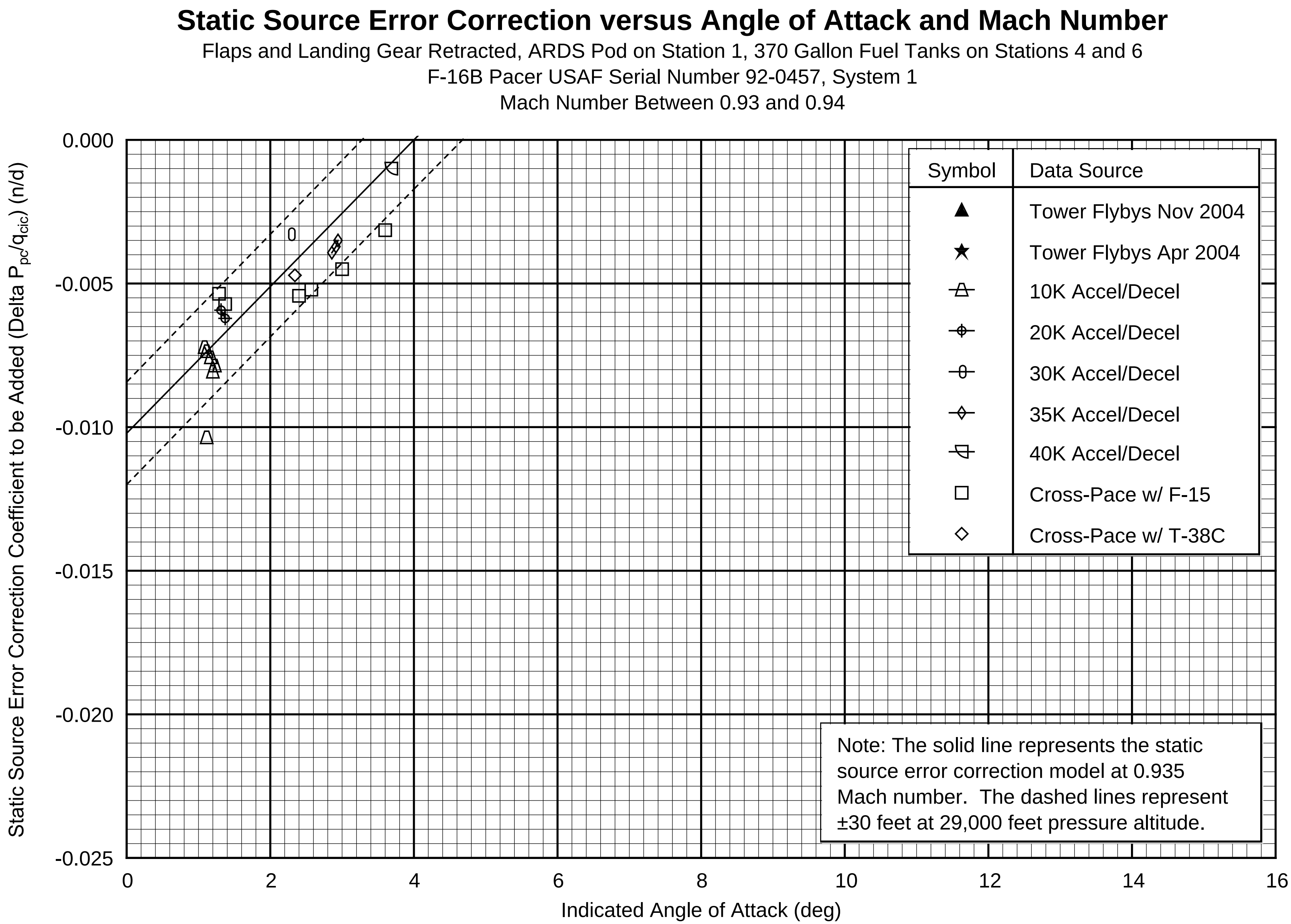

Figure C43 Static Source Error Corrections for Mach Numbers between 0.93 and 0.94 - All Data

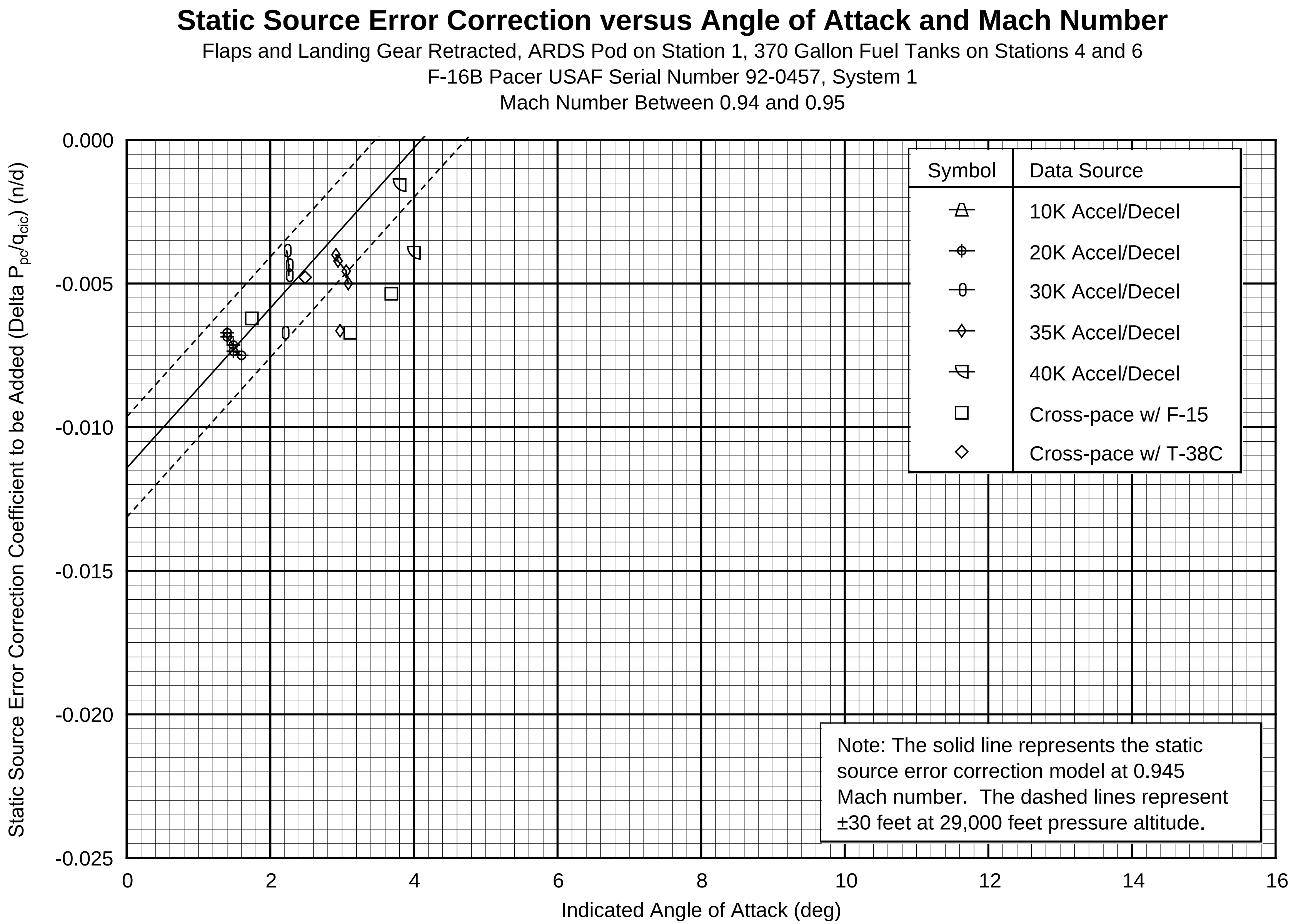

Figure C44 Static Source Error Corrections for Mach Numbers between 0.94 and 0.95 - All Data

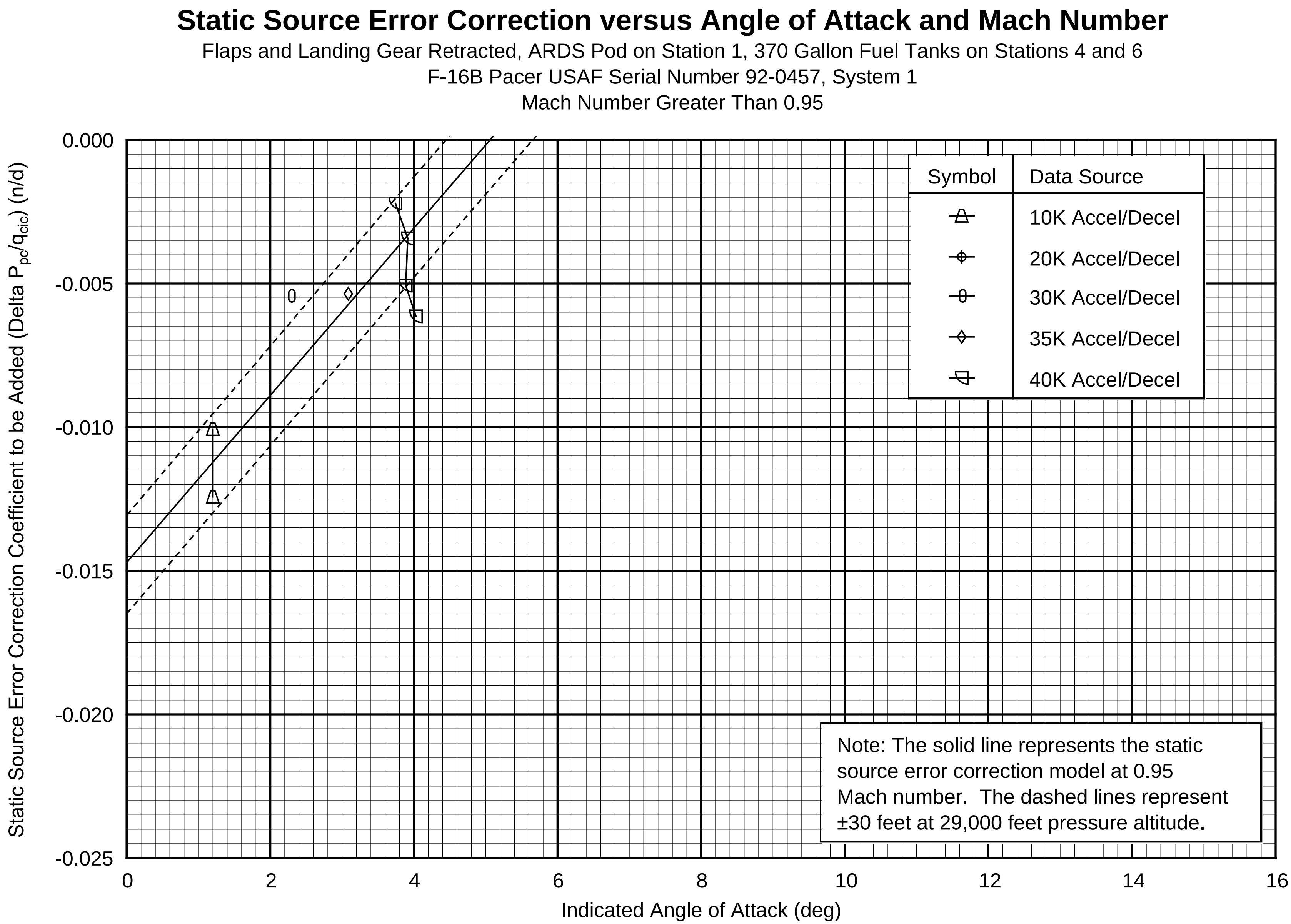

Figure C45 Static Source Error Corrections for Mach Numbers Greater Than 0.95 - All Data

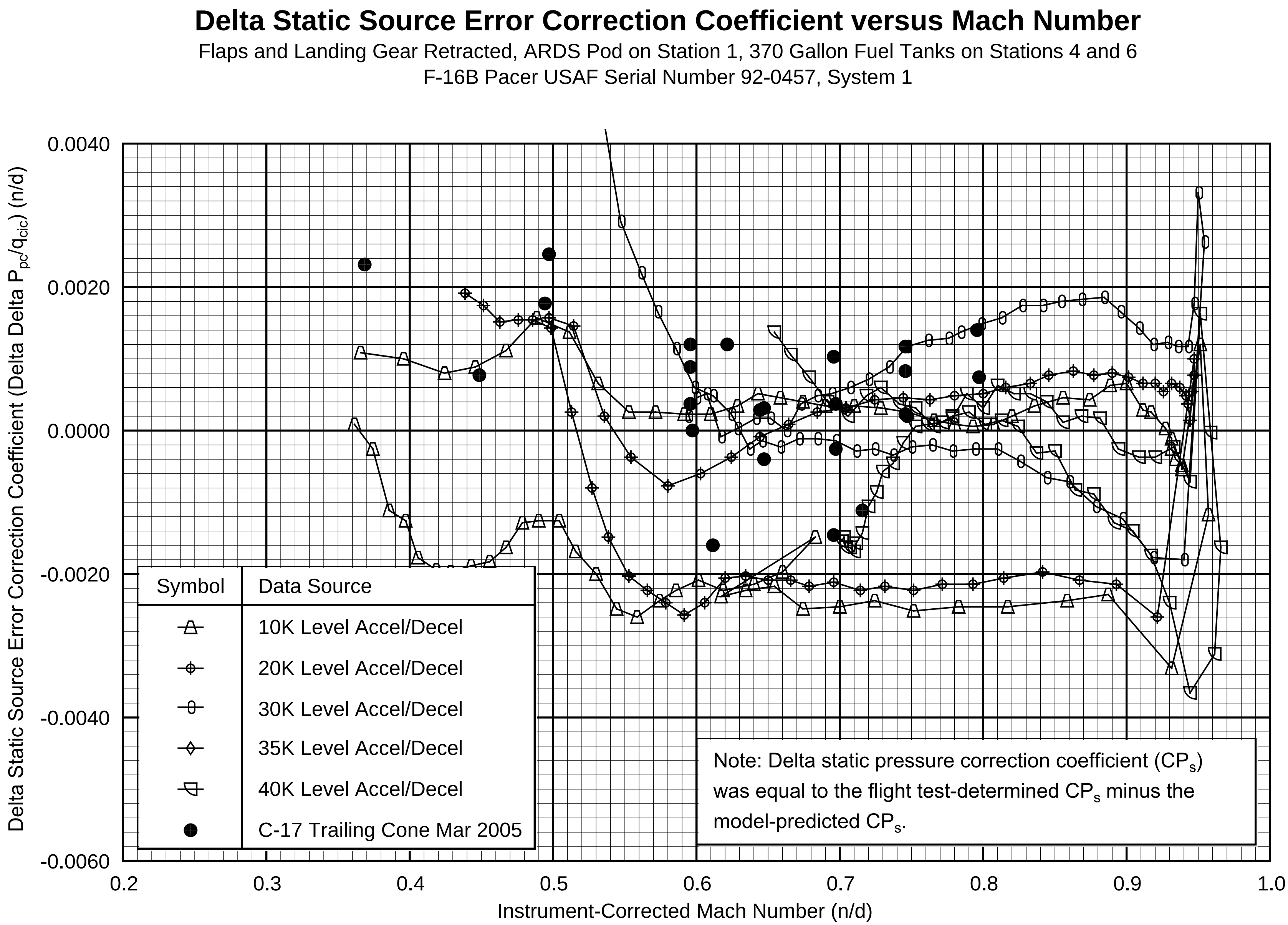

Figure C46 Comparison Between Flight Test Static Source Error Correction and Model - Static Source Error Correction Coefficient - All Data

Delta Altitude Static Source Error Correction versus Mach Number

Flaps and Landing Gear Retracted, ARDS Pod on Station 1, 370 Gallon Fuel Tanks on Stations 4 and 6
F-16B Pacer USAF Serial Number 92-0457, System 1

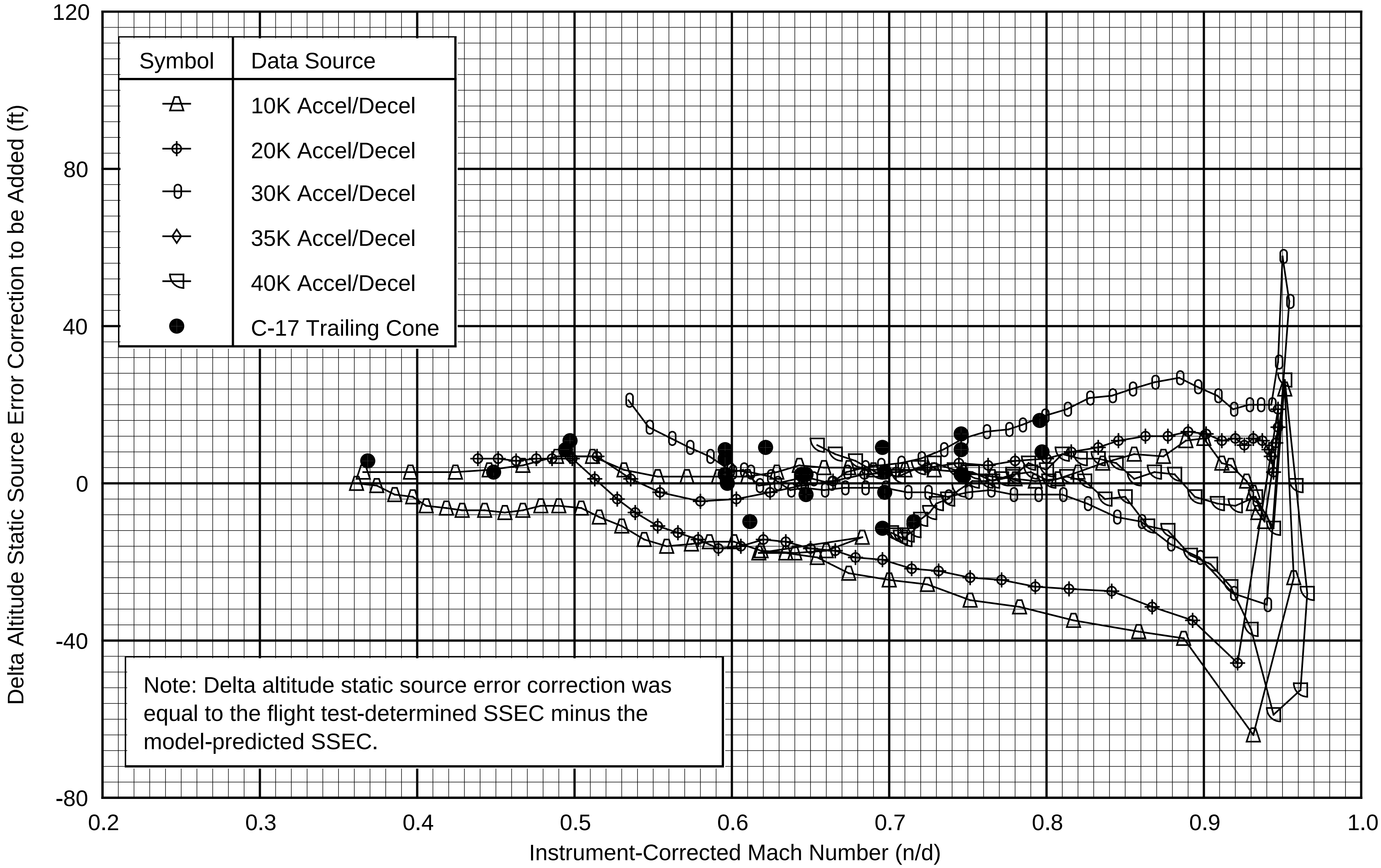

Figure C47 Comparison Between Flight Test Static Source Error Correction and Model - Altitude - All Data

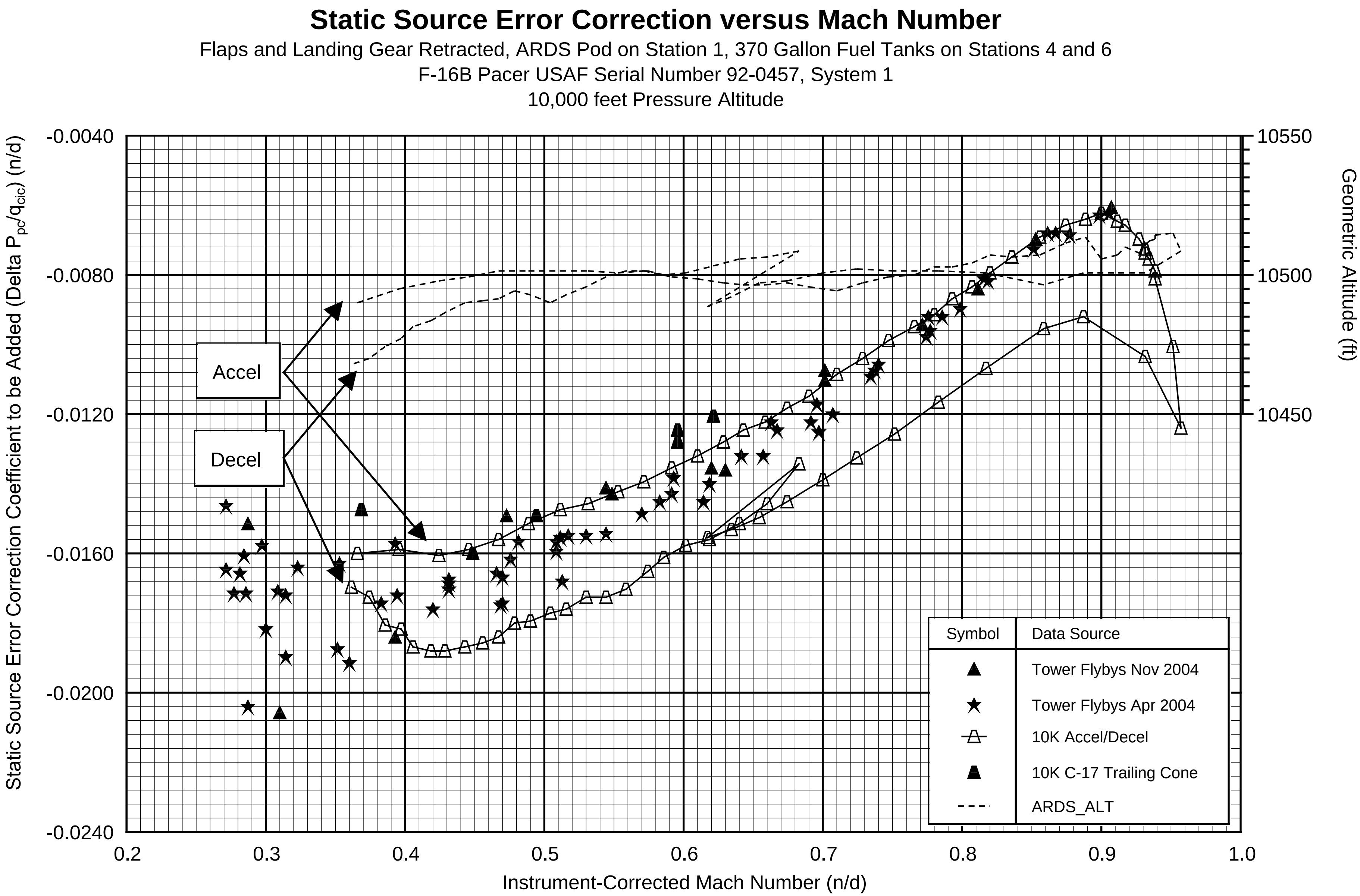

Figure C48 Static Source Error Corrections from the Level Accelerations and Decelerations - 10K

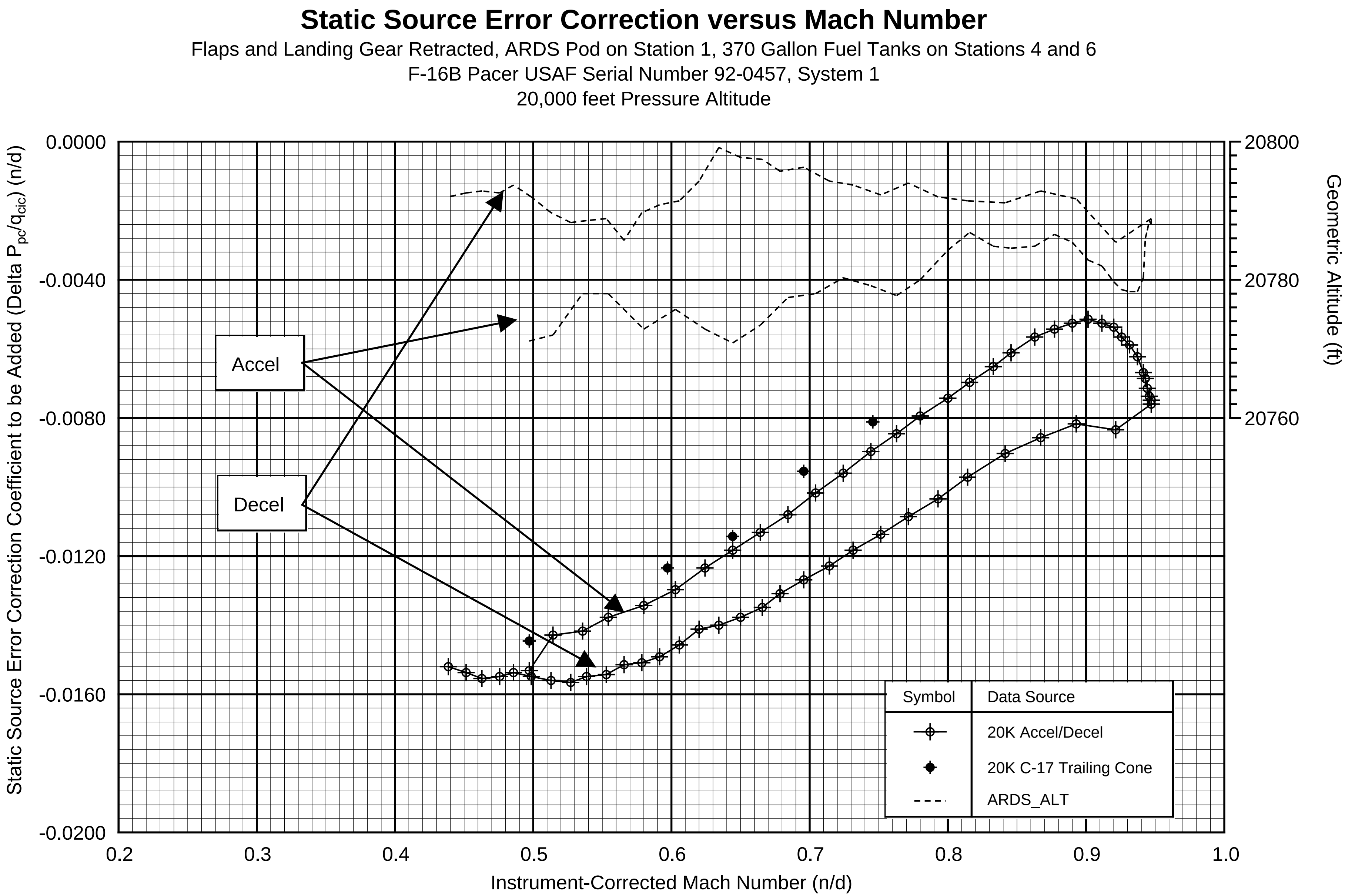

Figure C49 Static Source Error Corrections from the Level Accelerations and Decelerations - 20K

Static Source Error Correction versus Mach Number

Flaps and Landing Gear Retracted, ARDS Pod on Station 1, 370 Gallon Fuel Tanks on Stations 4 and 6
F-16B Pacer USAF Serial Number 92-0457, System 1
30,000 feet Pressure Altitude

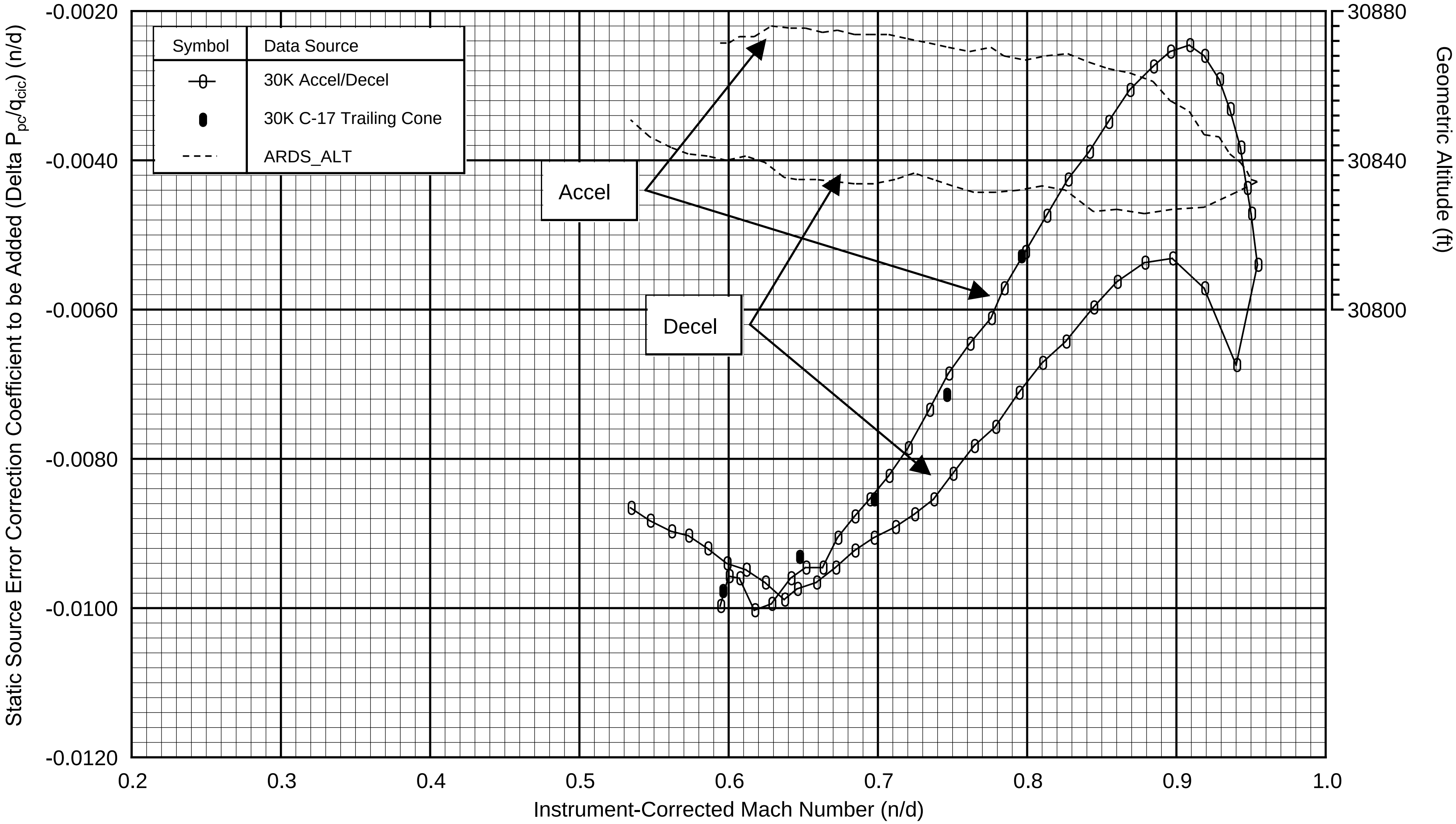

Figure C50 Static Source Error Corrections from the Level Accelerations and Decelerations - 30K

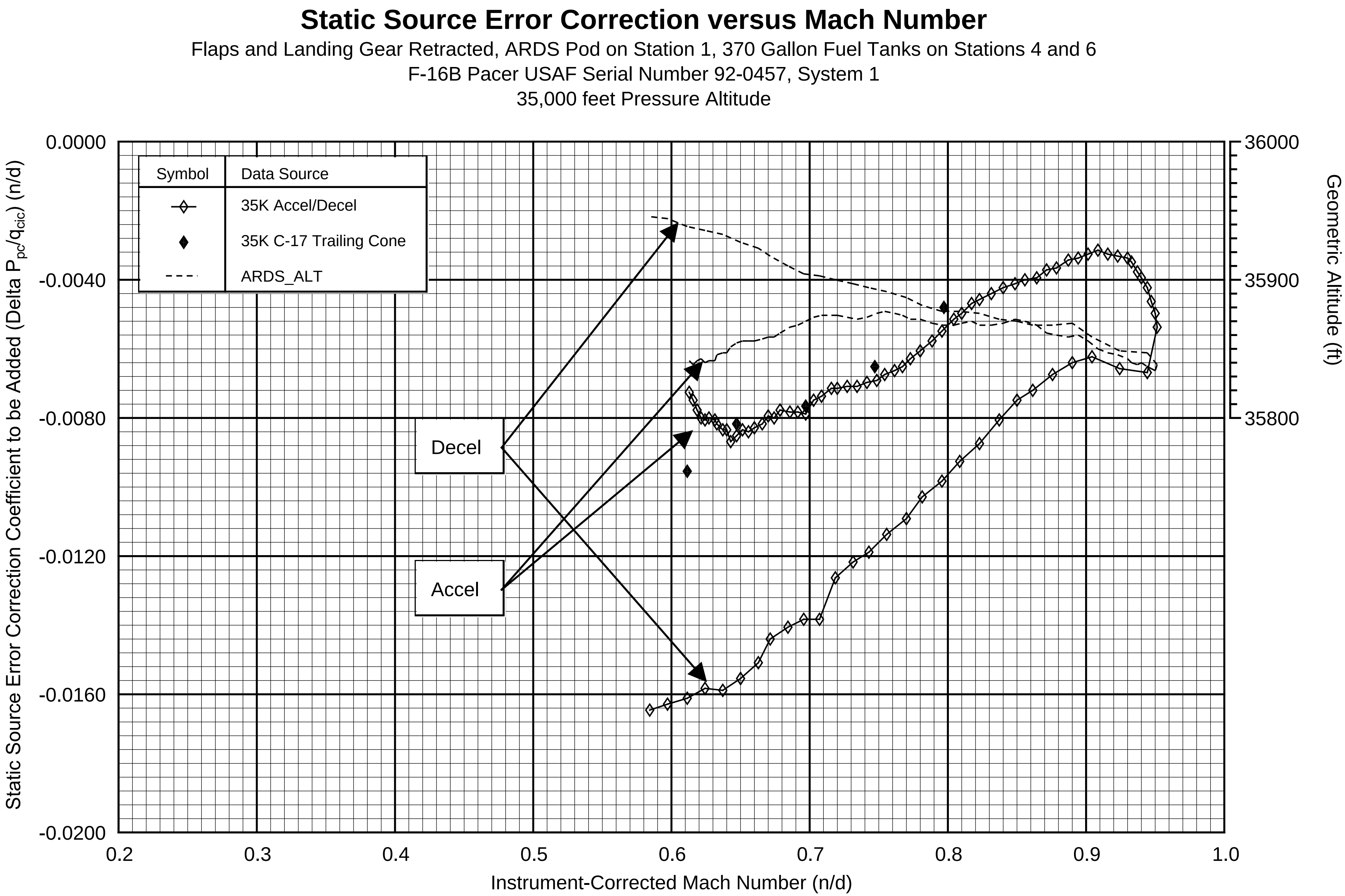

Figure C51 Static Source Error Corrections from the Level Accelerations and Decelerations - 35K

Static Source Error Correction versus Mach Number

Flaps and Landing Gear Retracted, ARDS Pod on Station 1, 370 Gallon Fuel Tanks on Stations 4 and 6
F-16B Pacer USAF Serial Number 92-0457, System 1
40,000 feet Pressure Altitude

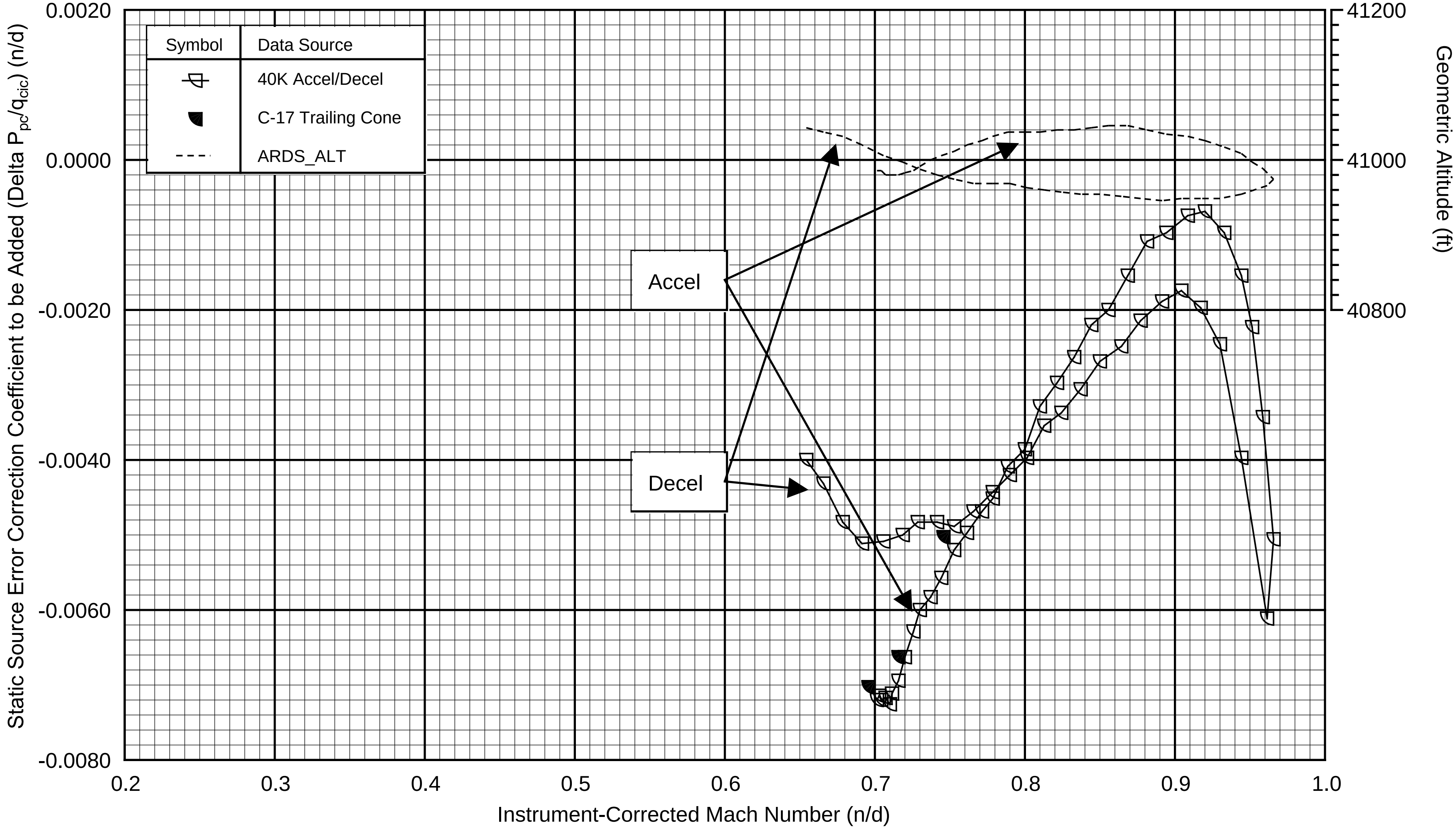

Figure C52 Static Source Error Corrections from the Level Accelerations and Decelerations - 40K

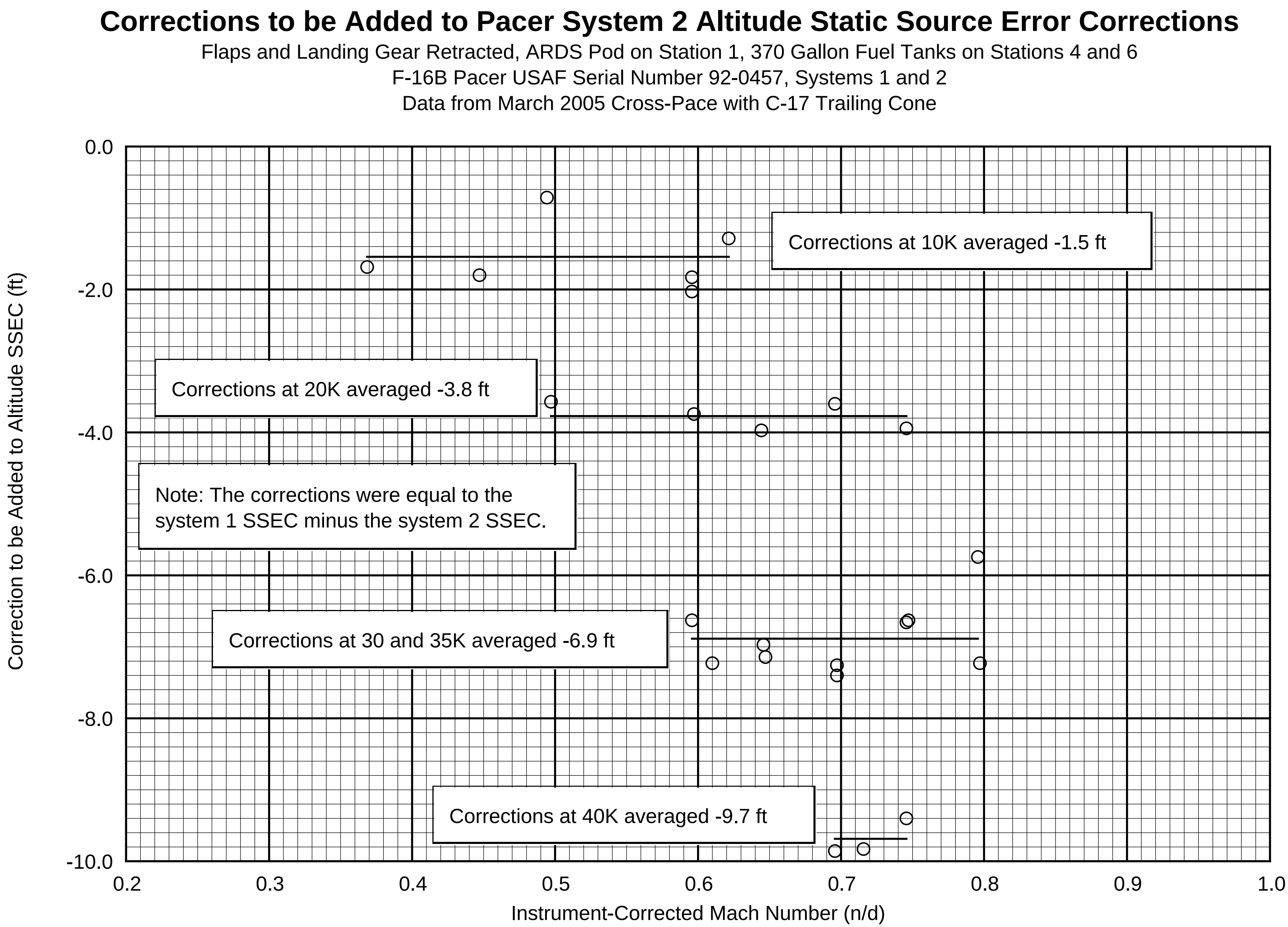

Figure C53 Corrections to be Added to Pacer System 2 Altitude Static Source Error Corrections

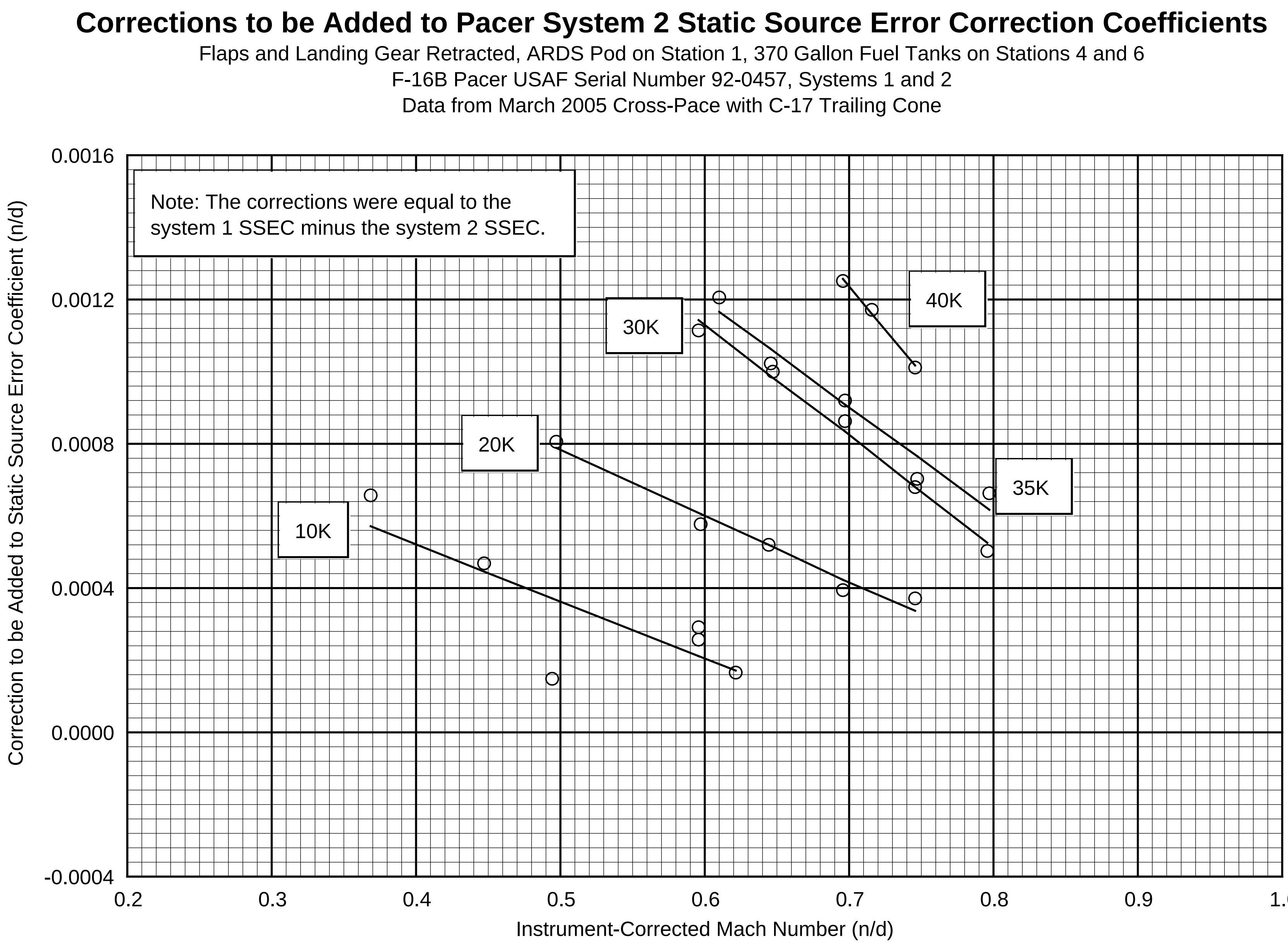

Figure C54 Corrections to be Added to Pacer System 2 Static Source Error Correction Coefficients

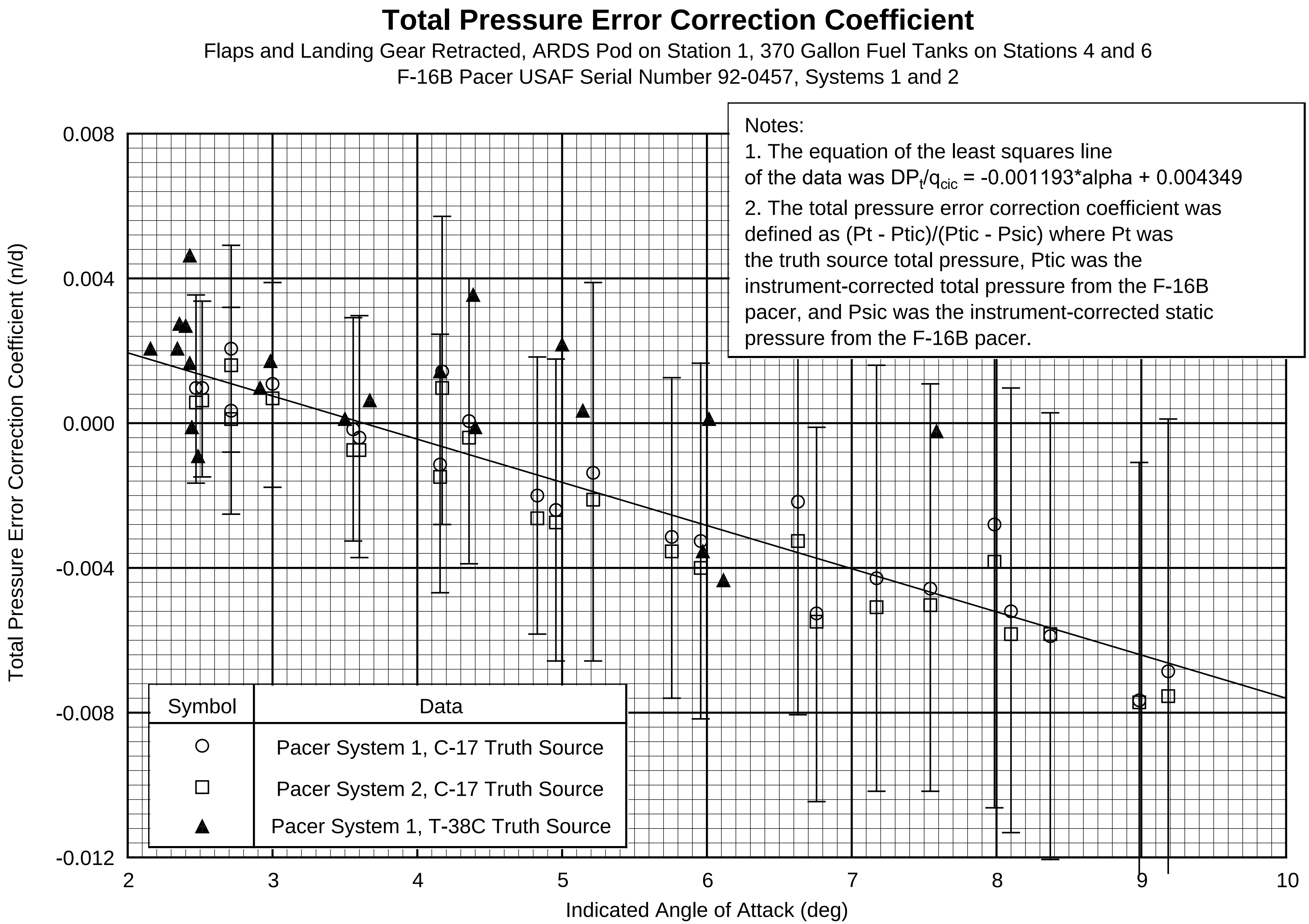

Figure C55 Total Pressure Error Correction Coefficient Versus Angle of Attack

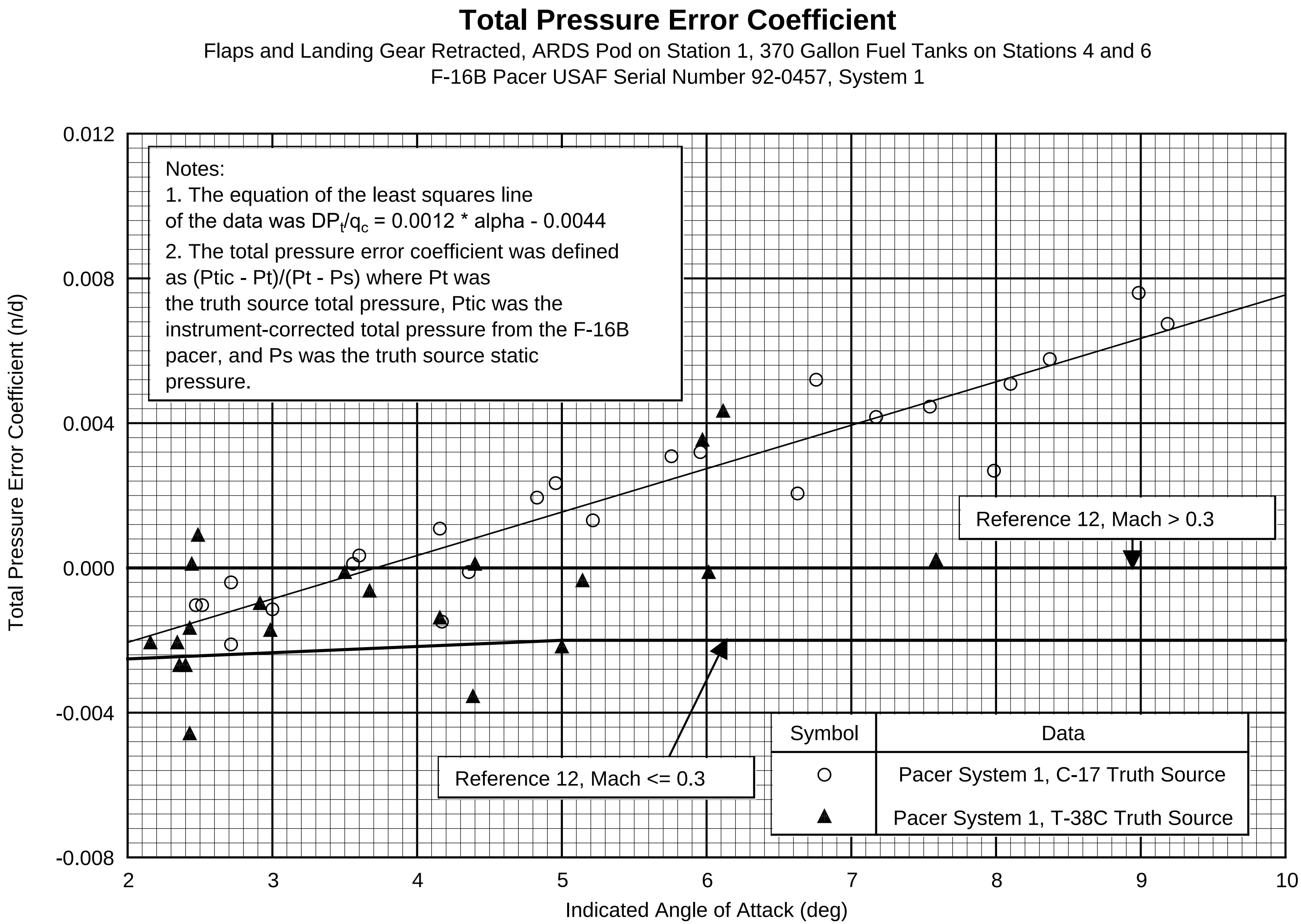

Figure C56 Total Pressure Error Coefficient Versus Angle of Attack

Total Air Temperature Probe Recovery Factor Determined from the Tower Flybys

Flaps and Landing Gear Retracted, ARDS Pod on Station 1, 370 Gallon Fuel Tanks on Stations 4 and 6
Production Total Temperature Probe
F-16B Pacer USAF Serial Number 92-0457

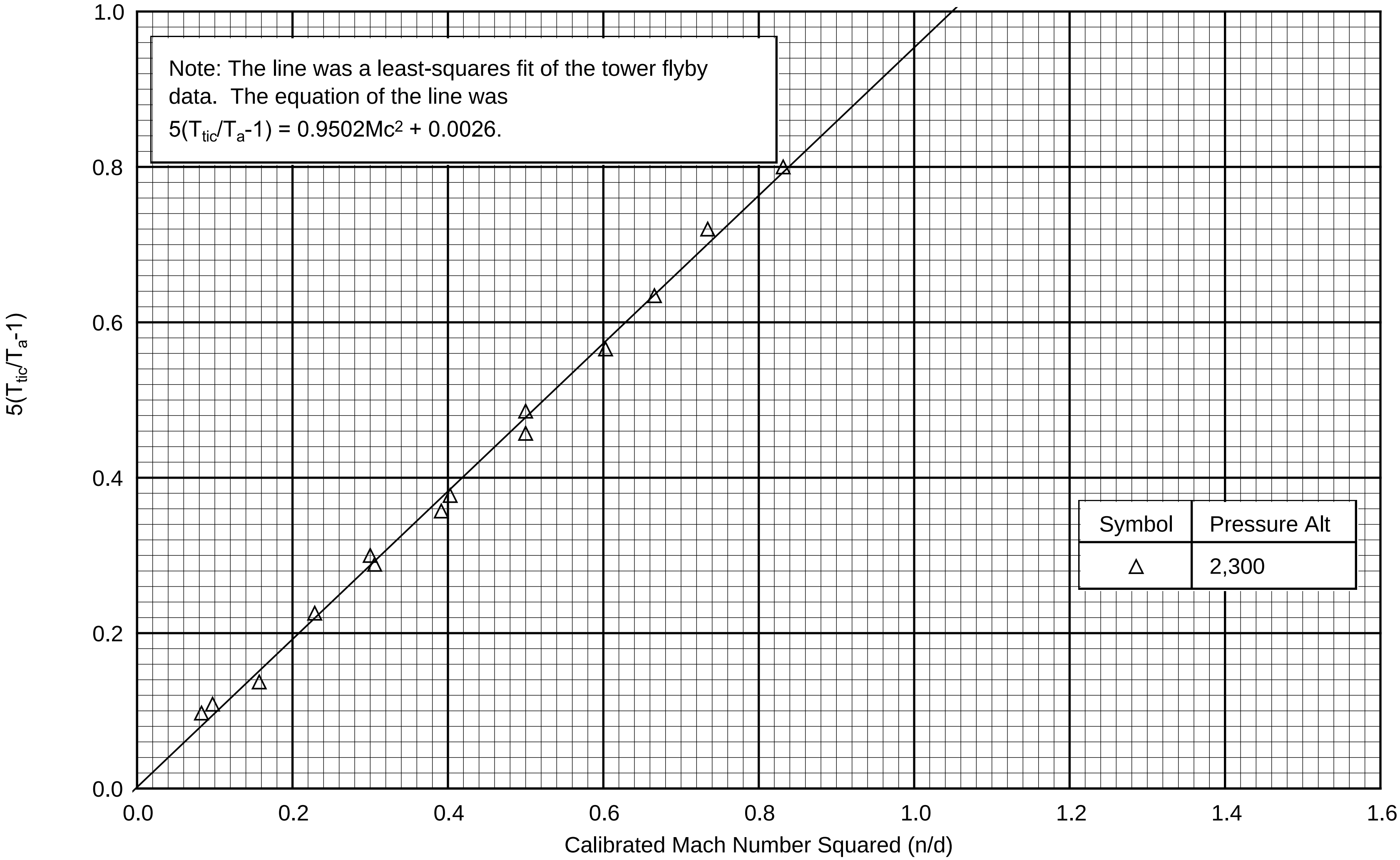

Figure C57 Production Total Air Temperature Probe Recovery Factor

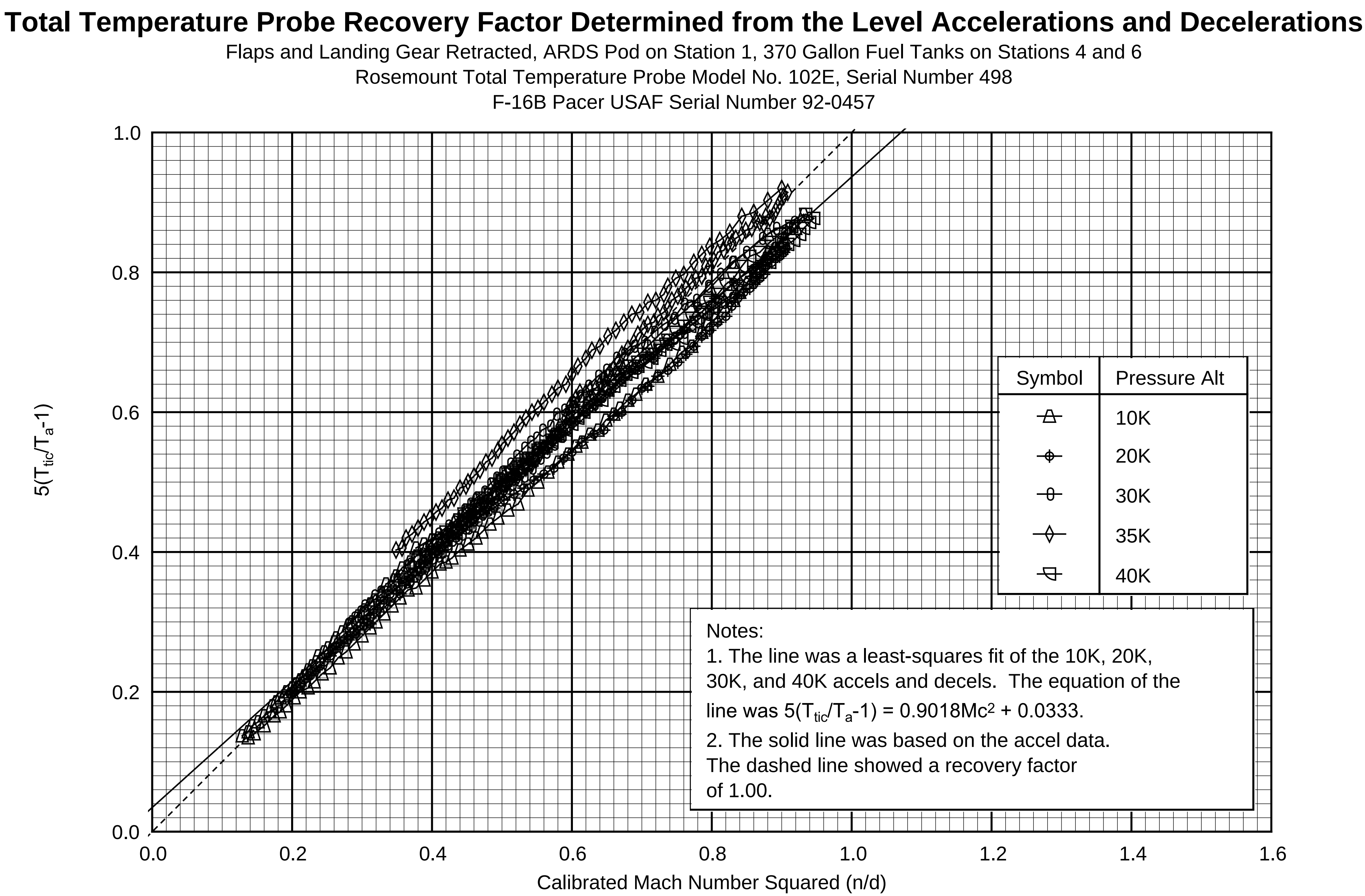

Figure C58 Total Air Temperature Probe Recovery Factor - All Altitudes

Total Temperature Probe Recovery Factor Determined from the Level Accelerations and Decelerations

Flaps and Landing Gear Retracted, ARDS Pod on Station 1, 370 Gallon Fuel Tanks on Stations 4 and 6
Rosemount Total Temperature Probe Model No. 102E, Serial Number 498
F-16B Pacer USAF Serial Number 92-0457

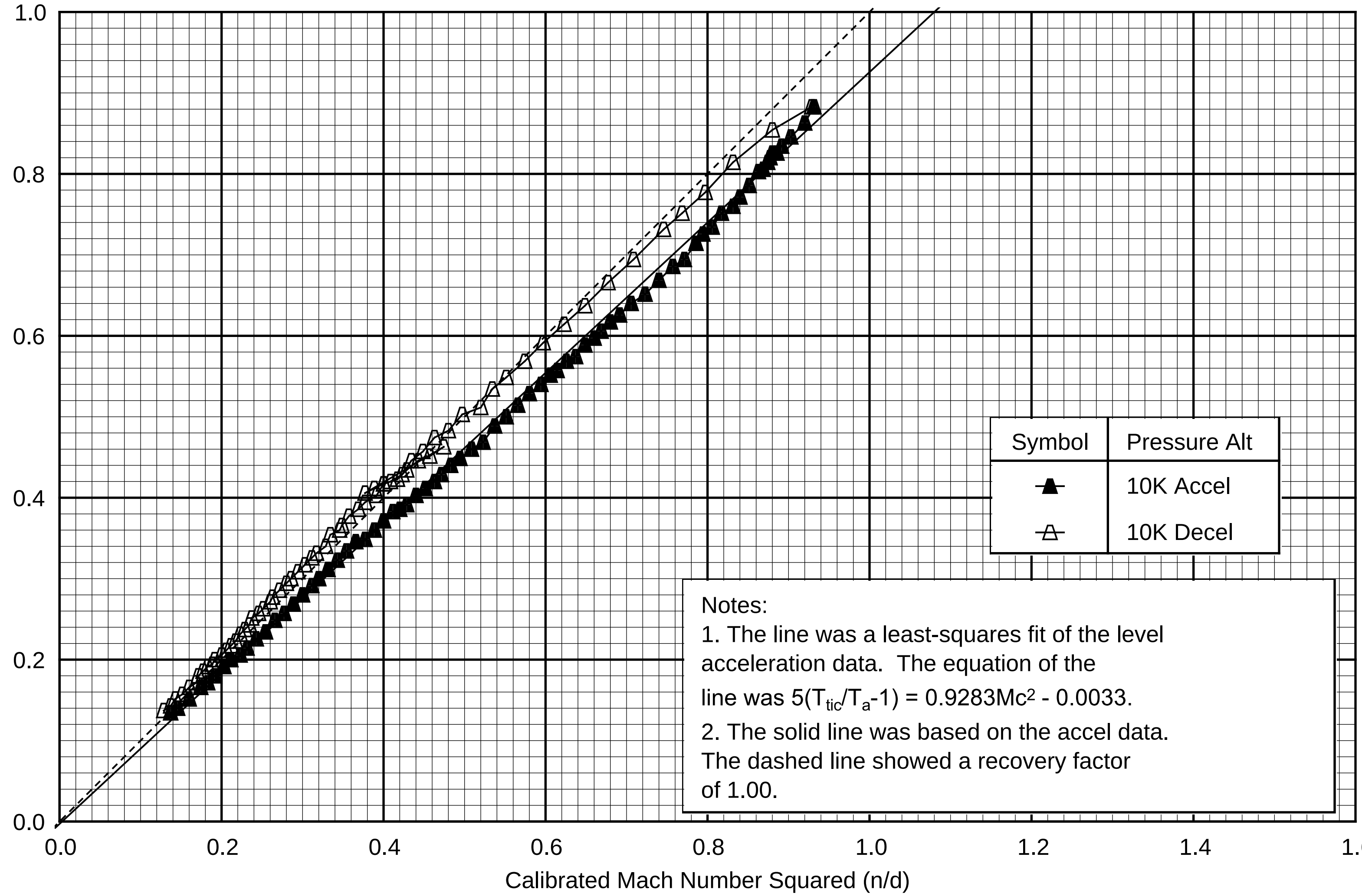

Figure C59 Total Air Temperature Probe Recovery Factor - 10K

Total Temperature Probe Recovery Factor Determined from the Level Accelerations and Decelerations

Flaps and Landing Gear Retracted, ARDS Pod on Station 1, 370 Gallon Fuel Tanks on Stations 4 and 6
Rosemount Total Temperature Probe Model No. 102E, Serial Number 498
F-16B Pacer USAF Serial Number 92-0457

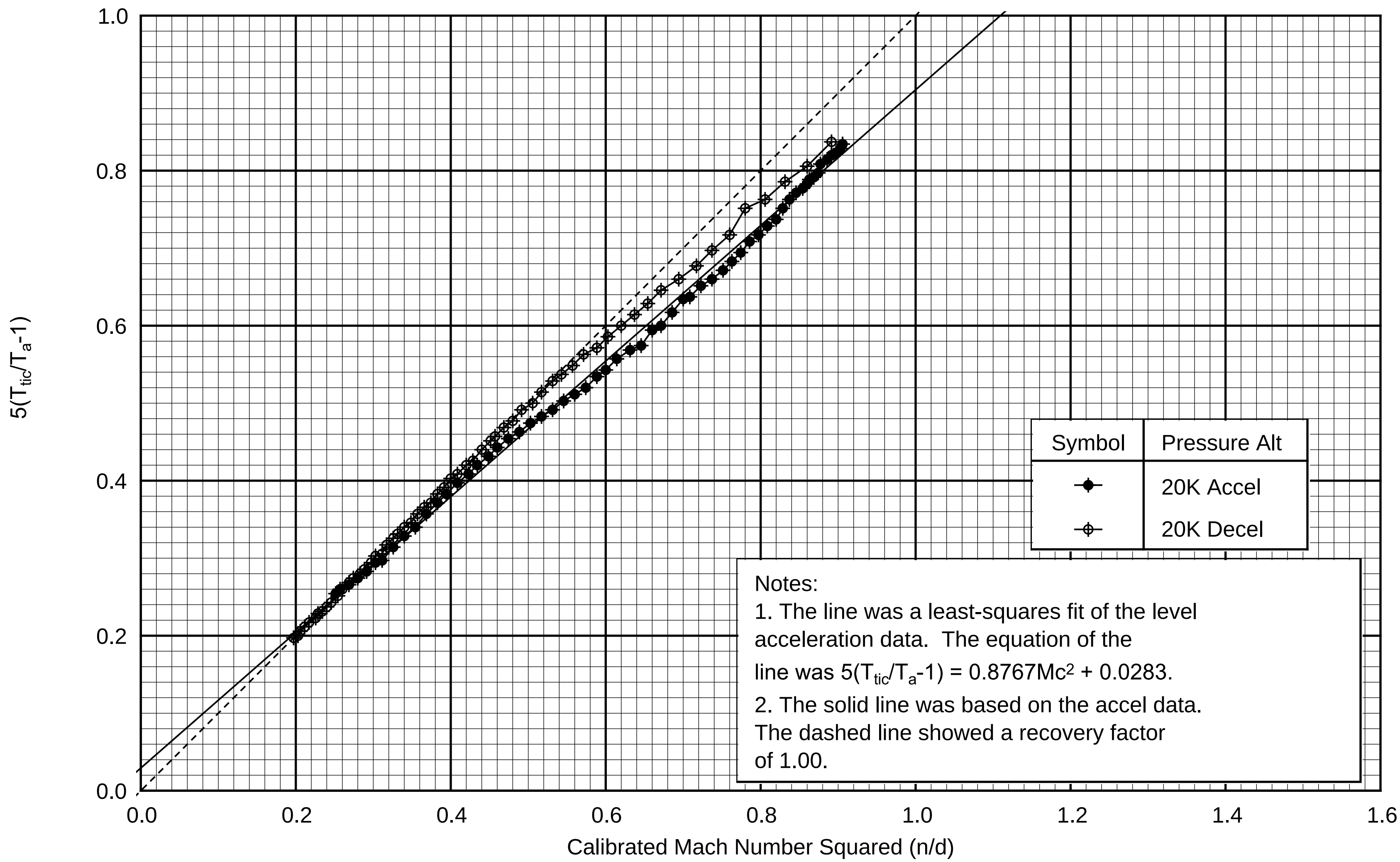

Figure C60 Total Air Temperature Probe Recovery Factor - 20K

Total Temperature Probe Recovery Factor Determined from the Level Accelerations and Decelerations

Flaps and Landing Gear Retracted, ARDS Pod on Station 1, 370 Gallon Fuel Tanks on Stations 4 and 6
Rosemount Total Temperature Probe Model No. 102E, Serial Number 498
F-16B Pacer USAF Serial Number 92-0457

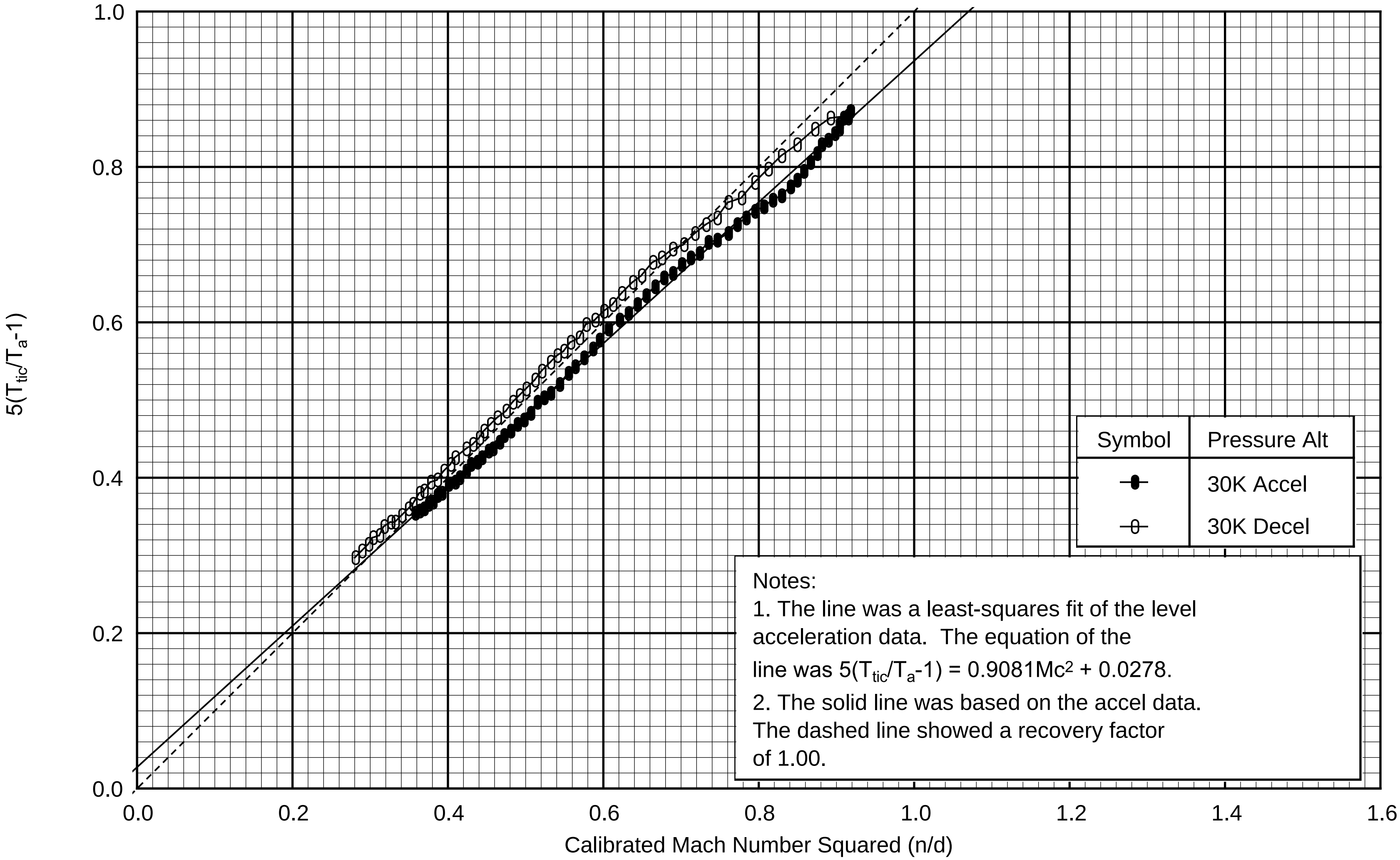

Figure C61 Total Air Temperature Probe Recovery Factor - 30K

Total Temperature Probe Recovery Factor Determined from the Level Accelerations and Decelerations

Flaps and Landing Gear Retracted, ARDS Pod on Station 1, 370 Gallon Fuel Tanks on Stations 4 and 6
Rosemount Total Temperature Probe Model No. 102E, Serial Number 498
F-16B Pacer USAF Serial Number 92-0457

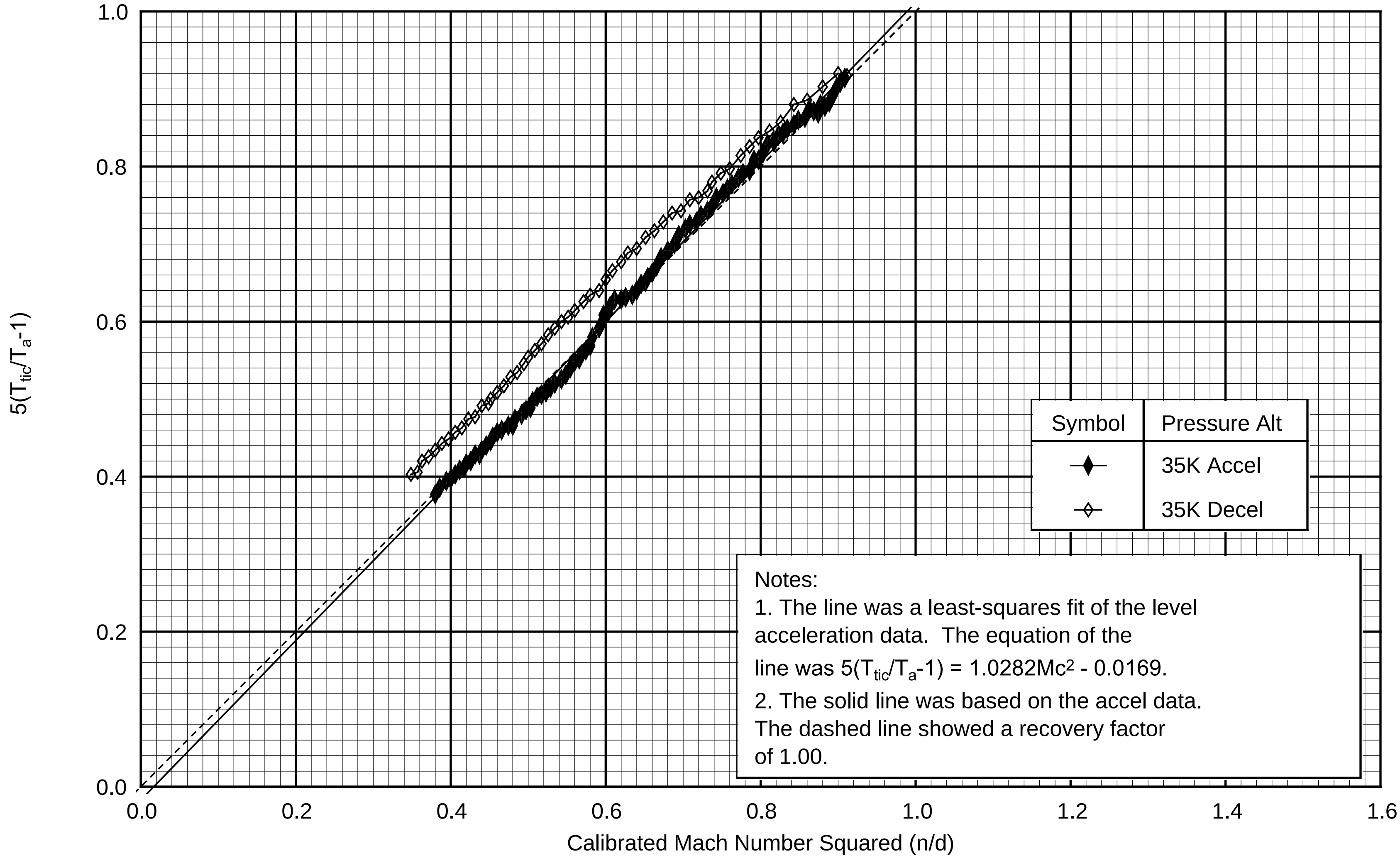

Figure C62 Total Air Temperature Probe Recovery Factor - 35K

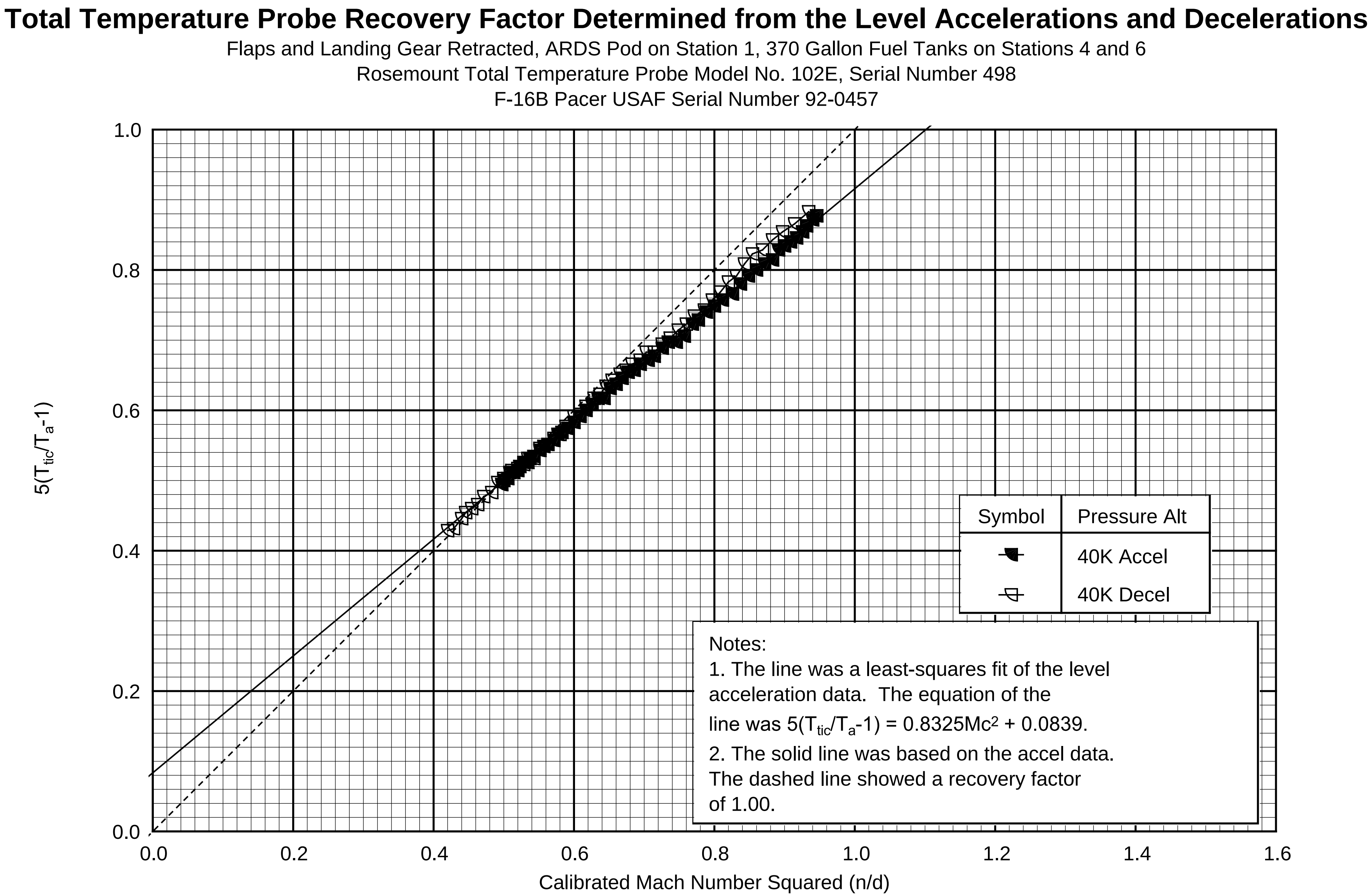

Figure C63 Total Air Temperature Probe Recovery Factor - 40K

Total Temperature Probe Recovery Factor Determined from the Cloverleaf Test Points

Flaps and Landing Gear Retracted, ARDS Pod on Station 1, 370 Gallon Fuel Tanks on Stations 4 and 6
Rosemount Total Temperature Probe Model No. 102E, Serial Number 498
F-16B Pacer USAF Serial Number 92-0457

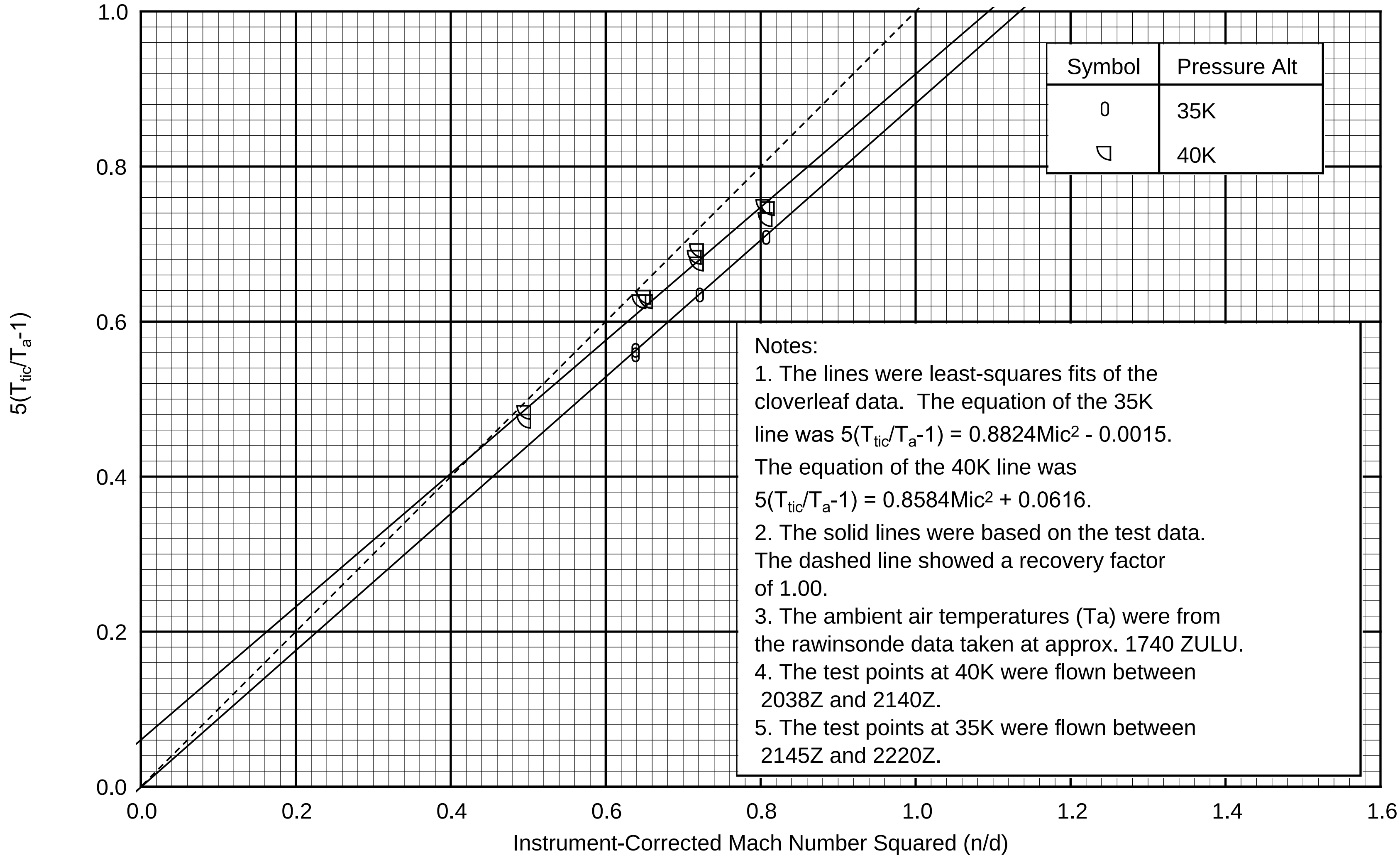

Figure C64 Total Air Temperature Probe Recovery Factor - Cloverleaf, 17:40Z Data

Total Temperature Probe Recovery Factor Determined from the Cloverleaf Test Points

Flaps and Landing Gear Retracted, ARDS Pod on Station 1, 370 Gallon Fuel Tanks on Stations 4 and 6
Rosemount Total Temperature Probe Model No. 102E, Serial Number 498
F-16B Pacer USAF Serial Number 92-0457

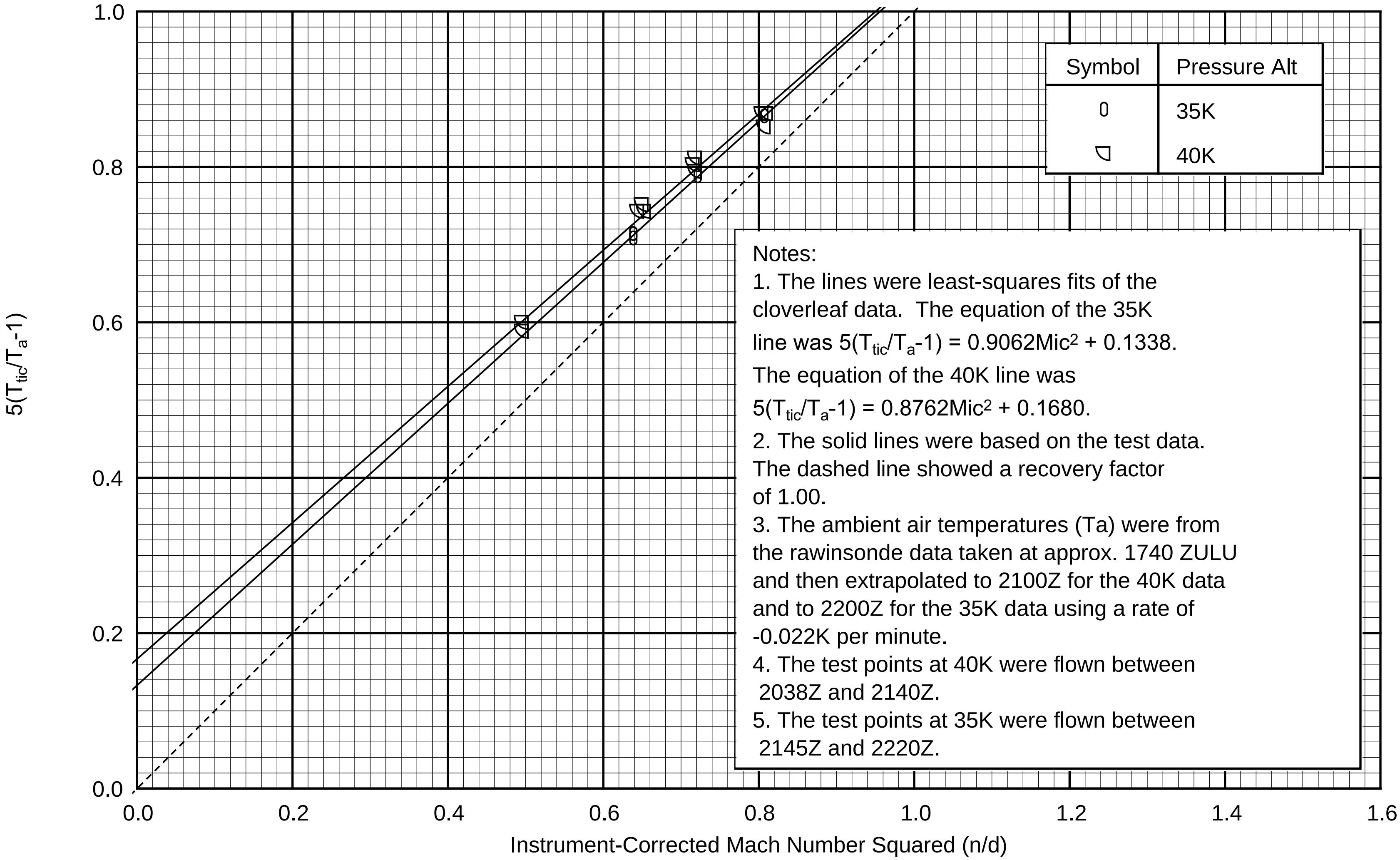

Figure C65 Total Air Temperature Probe Recovery Factor - Cloverleaf, Extrapolated Data

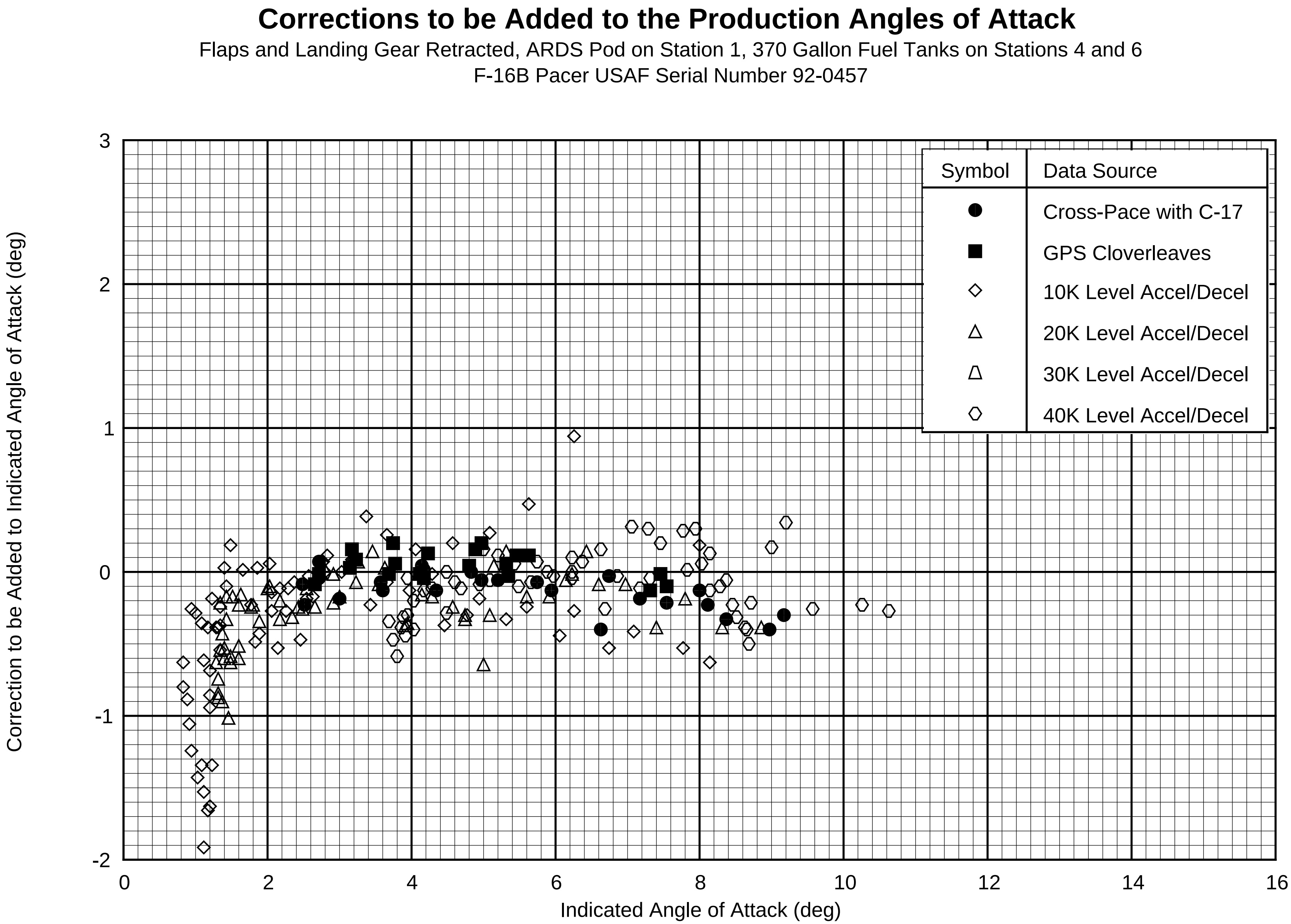

Figure C66 Corrections to Indicated Angles of Attack

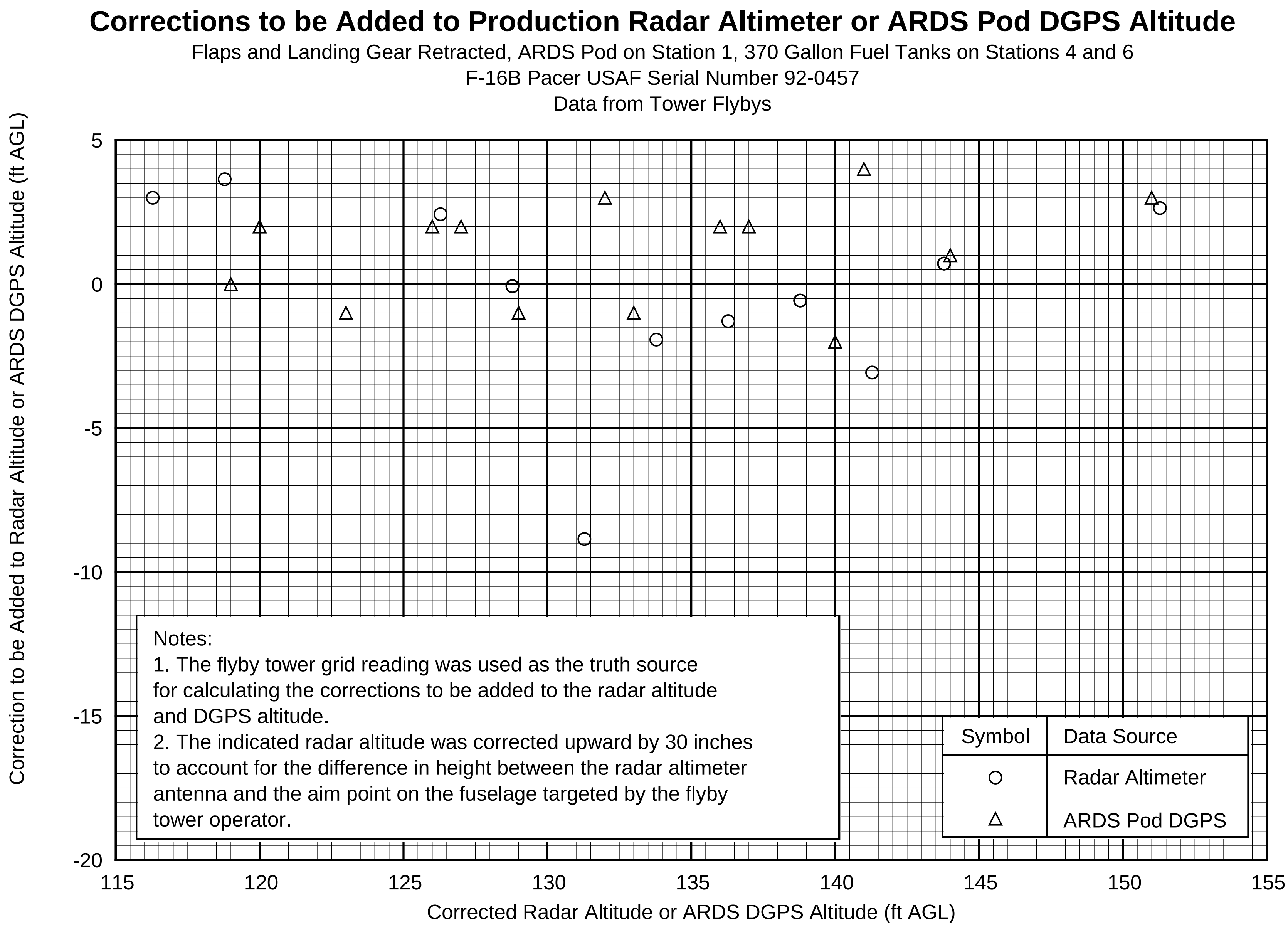

Figure C67 Corrections to be Added to Radar Altimeter or ARDS DGPS Altitude

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APPENDIX D - UNCERTAINTY ANALYSIS

OVERVIEW OF METHOD USED TO PROPAGATE UNCERTAINTIES

The methodology outlined in references 18 and 19 were used in this uncertainty analysis. The process is briefly summarized here for convenience.

The elemental uncertainties were listed in three general categories: calibration, data acquisition, and data reduction. These categories were for bookkeeping purposes only; the elemental uncertainties were combined in the final step. Two types of uncertainties were considered: bias and precision. Most bias, or systematic, errors were removed through calibration of the instruments. However, some bias errors remained after calibrating or were unknown. Precision errors, or random errors, were those errors that could not be removed through calibration. They were random in nature and could only be dealt with by statistical processes.

The elemental bias limits were combined using the root of the sum of the squares (RSS) equation:

$$B = \left(\sum_{i=1}^{n} B_i^2 \right)^{1/2} \tag{D1}$$

where B was the combined bias uncertainty and B_i were the elemental bias uncertainties.

The precision uncertainties were characterized by the precision index, S, which was the sample standard deviation of the measurements.

$$S = \left[\frac{\sum_{i=1}^{n} (x_i - \bar{x})^2}{n-1} \right]^{1/2} \tag{D2}$$

The precision limit, P, was estimated using the Student's t statistic:

$$P = tS \tag{D3}$$

Unless otherwise noted, the number of samples was assumed to exceed 30, and the value of t was assumed to equal 2. This resulted in an overall 95 percent confidence interval.

The elemental precision limits were combined using the RSS equation:

$$P = \left(\sum_{i=1}^{n} P_i^2 \right)^{1/2} \tag{D4}$$

The bias and precision uncertainties were kept separate until the final step, at which time they were combined using the RSS equation to estimate the total uncertainty in the result.

The bias and precision limits were propagated using the following equation.

$$w_y = \left[\sum_{i=1}^{m} \left(\frac{\partial y}{\partial x_i} w_{x,i} \right)^2 \right]^{1/2} \tag{D5}$$

where:

$$y = f(x_1, x_2, \ldots, x_m) \tag{D6}$$

and $w_{x,i}$ represented the uncertainty in the *i*th independent variable, and w_y represented the uncertainty, either bias or precision, in the result. The bias and precision limits were each propagated separately to the result using equation D5. The uncertainties in the result due to the bias and precision limits were combined using the following equation:

$$U_y = \left(B_y^2 + P_y^2 \right)^{1/2} \tag{D7}$$

where B_y was the bias limit of the result and P_y was the precision limit of the result.

UNCERTAINTY IN PACER AIR DATA SYSTEM

The uncertainty in the pacer air data system was estimated by considering the uncertainties in the measured total and static air pressures, the uncertainties in the static source error corrections, and the uncertainties in the measured total air temperatures. These uncertainties were propagated through equations B1 through B18 to estimate the uncertainties in calibrated Mach number, airspeed, and pressure altitude.

Uncertainty in Measured Total and Static Air Pressures:

The total and static air pressures were measured by pacer Pitot-static system 1 and Dual Sonix digital pressure encoder serial number (S/N) 8. The Dual Sonix was calibrated by 412TW/ENI personnel using a Ruska model 6610 air data test set and an environmental chamber. The Dual Sonix total pressure transducer was calibrated between 5 and 75 in Hg and the static pressure transducer was calibrated between 4 and 30 in Hg. The unit was placed in the environmental chamber and was calibrated at -55, -25, 0, 23, and 50 deg C. The unit was allowed to soak at each temperature before the calibration readings were made.

Table D1 presents the uncertainty analysis of the Dual Sonix pressure encoder. The combined uncertainty in instrument-corrected total pressure was ±0.0075 in Hg. The combined uncertainty in instrument-corrected static pressure was ±0.0033 in Hg. These combined uncertainties were calculated by taking the square root of the sum of the squares of the bias limit (*B*) and the precision limit (*tS*) for the total and static instrument-corrected pressures, lines 35 and 18 of table D1, respectively.

Table D1 Elemental Uncertainties for Dual Sonix Digital Pressure Encoders

Number	Variable	Error Type	Source	B	tS	N	Units	Notes
1	P_{si}	Calibration	Hysteresis	0.0004			in Hg	Sonix specification. 0.001% of 38.6844 in Hg.
2	P_{si}	Calibration	Repeatability		0.0019	>30	in Hg	Sonix specification. 0.005% of 38.6844 in Hg.
3	P_{si}	Calibration	Resolution		0.0001	>30	in Hg	Sonix specification.
4	P_{si}	Calibration	Long Term Drift	0.0019			in Hg	Sonix specification. 0.01% of 38.6844 in Hg per year. Assumed Sonix are re-calibrated every 6 months.
5	P_{si}	Data Acquisition	quantization		neg.		in Hg	Less than Sonix resolution.
6	P_{si}	Data Acquisition	quantization		neg.		in Hg	Less than Sonix resolution.
7	P_{si}	Data Reduction	None				in Hg	
8	$\mathbf{P_{si}}$	**All**	**Combined Uncertainty**	**0.0019**	**0.0019**		**in Hg**	**RSS of elemental uncertainties.**
9	$P_{s,Ruska}$	Calibration	Resolution		0.0003	>30	in Hg	Ruska specification, ±0.001% of 32 in Hg.
10	$P_{s,Ruska}$	Calibration	Repeatability		0.0006	>30	in Hg	Ruska specification, ±0.002% of 32 in Hg.
11	$P_{s,Ruska}$	Calibration	Linearity	0.0006			in Hg	Ruska specification, ±0.002% of 32 in Hg.
12	$P_{s,Ruska}$	Calibration	Hysteresis	0.000			in Hg	Ruska specification, ±0.000% of 32 in Hg.
13	$P_{s,Ruska}$	Data Acquisition	None				in Hg	
14	$P_{s,Ruska}$	Data Reduction	None				in Hg	
15	$\mathbf{P_{s,Ruska}}$	**All**	**Combined Uncertainty**	**0.0006**	**0.0007**		**in Hg**	**RSS of elemental uncertainties.**
16	ΔP_{sic}	Data Reduction	Standard Error of Estimate		0.0010	28	in Hg	Estimated from calibration data using SEE equation. Least squares equation was used to model the instrument error correction. N = 28, t = 2.048 for 95% confidence.

Table D1 Elemental Uncertainties for Dual Sonix Digital Pressure Encoders (Continued)

Number	Variable	Error Type	Source	B	tS	N	Units	Notes
17	ΔP_{sic}	Data Reduction	Temperature Effects	0.001			in Hg	Sensitivity of instrument error correction curve to temperature at 23 deg C was -0.0001 in Hg/deg C. Assumed transducer was always within ±10 deg C of 23 deg C.
18	$\mathbf{P_{sic}}$	**All**	**Propagated Uncertainty**	**0.0023**	**0.0023**		**in Hg**	**RSS of elemental uncertainties.**
19	P_{ti}	Calibration	Hysteresis	0.0008			in Hg	Sonix specification. 0.001% of 77.3688 in Hg.
20	P_{ti}	Calibration	Repeatability		0.0039	>30	in Hg	Sonix specification. 0.005% of 77.3688 in Hg.
21	P_{ti}	Calibration	Resolution		0.0001	>30	in Hg	Sonix specification.
22	P_{ti}	Calibration	Long Term Drift	0.0039			in Hg	Sonix specification. 0.01% of 77.3688 in Hg per year. Assumed Sonix are re-calibrated every 6 months.
23	P_{ti}	Data Acquisition	quantization		neg.		in Hg	Less than Sonix resolution.
24	P_{ti}	Data Reduction	None				in Hg	
25	P_{ti}	**All**	**Combined Uncertainty**	**0.0040**	**0.0039**		in Hg	**RSS of elemental uncertainties.**
26	$q_{c,Ruska}$	Calibration	Resolution		0.0007	>30	in Hg	Ruska specification, ±0.001% of 68 in Hg.
27	$q_{c,Ruska}$	Calibration	Repeatability		0.0014	>30	in Hg	Ruska specification, ±0.002% of 68 in Hg.
28	$q_{c,Ruska}$	Calibration	Linearity	0.0014			in Hg	Ruska specification, ±0.002% of 68 in Hg.
29	$q_{c,Ruska}$	Calibration	Hysteresis	0.000			in Hg	Ruska specification, ±0.000% of 68 in Hg.
30	$q_{c,Ruska}$	Data Acquisition	None				in Hg	
31	$q_{c,Ruska}$	Data Reduction	None				in Hg	
32	$\mathbf{q_{c,Ruska}}$	**All**	**Combined Uncertainty**	**0.0014**	**0.0015**		**in Hg**	**RSS of elemental uncertainties.**

Table D1 Elemental Uncertainties for Dual Sonix Digital Pressure Encoders (Concluded)

Number	Variable	Error Type	Source	B	tS	N	Units	Notes
33	ΔP_{tic}	Data Reduction	Standard Error of Estimate		0.00208	30	in Hg	Estimated from calibration data using SEE equation. Least squares equation was used to model the instrument error correction. N = 30, t = 2.042 for 95% confidence.
34	ΔP_{tic}	Data Reduction	Temperature Effects	0.004			in Hg	Sensitivity of instrument error correction curve to temperature at 23 deg C was -0.0004 in Hg/deg C. Assumed transducer was always within ±10 deg C of 23 deg C.
35	$\mathbf{P_{tic}}$	**All**	**Propagated Uncertainty**	**0.0058**	**0.0047**		**in Hg**	**RSS of elemental uncertainties.**

Notes:
1. P_{si} - indicated static pressure.
2. $P_{s,Ruska}$ - static pressure from Ruska model 6610 Air Data Test Set.
3. ΔP_{sic} - instrument error correction to be added to static pressure.
4. P_{sic} - instrument-corrected static pressure.
5. P_{ti} - indicated total pressure.
6. $q_{c,Ruska}$ - differential pressure from Ruska model 6610 Air Data Test Set.
7. ΔP_{tic} - instrument error correction to be added to total pressure.
8. P_{tic} - instrument-corrected total pressure.
9. B - bias limit.
10. t - Student's t statistic.
11. S - Precision index.
12. N - number of samples.
13. RSS - square root of the sum of the squares.
14. SEE - standard error of estimate.
15. Bold text denotes combined uncertainties.

Uncertainty in Static Source Error Corrections:

The static source error corrections were determined through flight calibration using the tower flyby, cross-pace, and trailing cone methods. The tower flyby calibration data were acquired on the tower flyby range at Edwards AFB, California. Cross-pace calibration data were obtained by flying in formation with a calibrated F-15B pacer and a calibrated T-38C aircraft. The trailing cone calibration data were acquired while flying in formation with a C-17A aircraft equipped with a trailing cone.

Uncertainty analyses were only performed for the tower flyby and trailing cone methods because these data were used to develop the static source error correction curves. The cross-pace data were used to build confidence in the static source error correction curves.

Uncertainty in Tower Flyby Method.

The tower flyby method was an altitude method that used an instrumented tower to independently determine the ambient air pressure and temperature through which the aircraft was flying. The aircraft flew straight and level along a line painted on the lakebed and passed in front of the tower. The observer sighted through a peephole to locate the aircraft on a calibrated grid as it flew past the tower. The grid reading was correlated with the height above ground level of the aircraft. Instrumentation in the tower measured ambient air pressure and temperature at the elevation of the zero grid line (ZGL). The values for pressure and temperature were extrapolated up to the height of the aircraft using standard lapse rates.

The ambient air pressure at the zero grid line (equation B40) was measured by a Setra model 370 digital pressure gauge. A NovaLynx model 230-355 hand-held barometer and altimeter was used as a backup to the Setra. The ambient air temperature at the zero grid line (equation B41) was measured by an Omega model HH41 or HH42 thermistor thermometer. Table D2 lists the elemental bias and precision limits for these instruments.

Table D2 Elemental Uncertainties of Tower Flyby Method

Number	Variable	Error Type	Source	B	tS	N	Units	Notes
1	$H_{p,ZGL}$	Calibration	Accuracy	0.0065			in Hg	Setra specification. ±0.02% of 32.4830 in Hg. Included effects of non-linearity, hysteresis and non-repeatability. At 2,300 ft pressure altitude, this corresponded to ±6 ft.
2	$H_{p,ZGL}$	Calibration	Non-linearity	0.0039			in Hg	Setra specification. ±0.012% of 32.4830 in Hg.
3	$H_{p,ZGL}$	Calibration	Hysteresis	0.0032			in Hg	Setra specification. ±0.010% of 32.4830 in Hg.
4	$H_{p,ZGL}$	Calibration	Non-repeatability		0.0032	>30	in Hg	Setra specification. ±0.010% of 32.4830 in Hg.
5	$H_{p,ZGL}$	Calibration	Resolution		0.0001	>30	in Hg	Resolution of Setra pressure display.
6	$\mathbf{H_{p,ZGL}}$	**All**	**Combined Uncertainty**	**0.0050**	**0.0032**		**in Hg**	**RSS of elemental uncertainties 2 through 5.**
7	$\mathbf{H_{p,ZGL}}$	**All**	**Combined Uncertainty**	**5**	**3**		**ft**	**Feet calculated using 1 ft per 0.001 in Hg.**
8	$H_{p,ZGL}$ [10]	Calibration	Accuracy	0.01			in Hg	NovaLynx specification. ±0.02% of 35.43 in Hg.
9	$H_{p,ZGL}$ [10]	Calibration	Resolution		0.01	>30	in Hg	Resolution of NovaLynx pressure display. Unit also had resolution of 1 ft.
10	$\mathbf{H_{p,ZGL}}$ [10]	**All**	**Combined Uncertainty**	**0.0100**	**0.0100**	**>30**	**in Hg**	**RSS of elemental uncertainties.**
11	$H_{p,ZGL}$	Data Acquisition	None	0	0		in Hg	Assumed observer correctly sighted aircraft, read grid, and recorded data.
12	$H_{p,ZGL}$	Data Reduction	Standard Error of Estimate					Estimated from flyby tower weather data using SEE equation. Least squares equation was used to model the zero grid line pressure altitude versus time. The SEE's for each tower flyby data are listed below.
13	$H_{p,ZGL}$	Data Reduction	Standard Error of Estimate		11	30	ft	Tower flyby date 7 Apr 2004
14	$H_{p,ZGL}$	Data Reduction	Standard Error of Estimate		5	29	ft	Tower flyby date 12 Apr 2004
15	$H_{p,ZGL}$	Data Reduction	Standard Error of Estimate		3	32	ft	Tower flyby date 13 Apr 2004

Table D2 Elemental Uncertainties of Tower Flyby Method (Continued)

Number	Variable	Error Type	Source	B	tS	N	Units	Notes
16	$H_{p,ZGL}$	Data Reduction	Standard Error of Estimate		3	19	ft	Tower flyby date 30 Apr 2004
17	$H_{p,ZGL}$	Data Reduction	Standard Error of Estimate		11	41	ft	Tower flyby date 23 Nov 2004
18	$\mathbf{H_{p,ZGL}}$	**All**	**Combined Uncertainty**	**5**	**11**		**ft**	**RSS of elemental uncertainties, 7 Apr 2004**
19	$\mathbf{H_{p,ZGL}}$	**All**	**Combined Uncertainty**	**5**	**6**		**ft**	**RSS of elemental uncertainties, 12 Apr 2004**
20	$\mathbf{H_{p,ZGL}}$	**All**	**Combined Uncertainty**	**5**	**4**		**ft**	**RSS of elemental uncertainties, 13 Apr 2004**
21	$\mathbf{H_{p,ZGL}}$	**All**	**Combined Uncertainty**	**5**	**4**		**ft**	**RSS of elemental uncertainties, 30 Apr 2004**
22	$\mathbf{H_{p,ZGL}}$	**All**	**Combined Uncertainty**	**5**	**11**		**ft**	**RSS of elemental uncertainties, 23 Nov 2004**
23	$T_{a,ZGL}$	Calibration	Accuracy	0.15			deg C	Omega HH-41 Thermometer specification. Used 10093-3 probe.
24	$T_{a,ZGL}$	Data Acquisition	None					Assumed observer correctly read and recorded data.
25	$T_{a,ZGL}$	Data Reduction	Standard Error of Estimate					Estimated from flyby tower weather data using SEE equation. Least squares equation was used to model the zero grid line ambient air temperature versus time. The SEE's for each tower flyby data are listed below.
26	$T_{a,ZGL}$	Data Reduction	Standard Error of Estimate		0.4	30	deg C	Tower flyby date 7 Apr 2004
27	$T_{a,ZGL}$	Data Reduction	Standard Error of Estimate		0.9	29	deg C	Tower flyby date 12 Apr 2004
28	$T_{a,ZGL}$	Data Reduction	Standard Error of Estimate		1.1	32	deg C	Tower flyby date 13 Apr 2004
29	$T_{a,ZGL}$	Data Reduction	Standard Error of Estimate		2	19	deg C	Tower flyby date 30 Apr 2004
30	$T_{a,ZGL}$	Data Reduction	Standard Error of Estimate		1.9	41	deg C	Tower flyby date 23 Nov 2004

Table D2 Elemental Uncertainties of Tower Flyby Method (Concluded)

Number	Variable	Error Type	Source	B	tS	N	Units	Notes
31	$\mathbf{T_{a,ZGL}}$	**All**	**Combined Uncertainty**	**0.2**	**0.4**		**deg C**	**RSS of elemental uncertainties, 7 Apr 2004**
32	$\mathbf{T_{a,ZGL}}$	**All**	**Combined Uncertainty**	**0.2**	**0.9**		**deg C**	**RSS of elemental uncertainties, 12 Apr 2004**
33	$\mathbf{T_{a,ZGL}}$	**All**	**Combined Uncertainty**	**0.2**	**1.1**		**deg C**	**RSS of elemental uncertainties, 13 Apr 2004**
34	$\mathbf{T_{a,ZGL}}$	**All**	**Combined Uncertainty**	**0.2**	**2.0**		**deg C**	**RSS of elemental uncertainties, 30 Apr 2004**
35	$\mathbf{T_{a,ZGL}}$	**All**	**Combined Uncertainty**	**0.2**	**1.9**		**deg C**	**RSS of elemental uncertainties, 23 Nov 2004**
36	Δh	Calibration	Slope	0.0			ft/grid	$\Delta h = 31.48 \times$ (grid reading). Assumed zero error in slope of equation.
37	Δh	Data Acquisition	Grid Reading Error		0.1	>30	Grid	Precision error of reading grid.
38	Δh	Data Reduction	None	0	0			
39	$\mathbf{\Delta h}$	**All**	**Combined Uncertainty**	**0**	**0.1**	**>30**	**Grid**	**RSS of elemental uncertainties.**
40	$\mathbf{\Delta h}$	**All**	**Combined Uncertainty**	**0**	**3**		**ft**	**Feet calculated using 31.48 feet per grid reading.**

Notes: 1. $H_{p,ZGL}$ - ambient air pressure (or pressure altitude) measured at the elevation of the zero grid line.
2. $T_{a,ZGL}$ - ambient air temperature measured at the elevation of the zero grid line.
3. B - bias limit.
4. t - Student's t statistic.
5. S - Precision index.
6. N - number of samples.
7. RSS - square root of the sum of the squares.
8. SEE - standard error of estimate.
9. Bold text denotes combined uncertainties.
10. The Setra was primarily used for the pressure measurements. The NovaLynx was used as a backup and its specifications are provided for reference.

The pressure error at the tower due to wind was neglected because the tower flyby testing generally occurred on days with calm or light winds. The pressure and temperature spatial variability (between the tower and the location of the aircraft) were also neglected. The uncertainty in pressure altitude at the elevation of the zero grid line ranged between ±6 and ±12 feet and averaged ±9 feet (lines 18 through 22 of table D2). The uncertainty in ambient air temperature at the zero grid line ranged between ±0.4 and ±2.0 deg C and averaged ±1.3 degrees C (lines 31 through 35 of table D2).

The bias limit of the grid reading was assumed to equal zero; there was assumed to be zero error in the slope and zero bias in equation B41. A precision limit of a tenth of a grid reading ($\pm 0.1 \cdot GR$) was assumed based on the ability of a typical observer to visually subdivide each grid segment into to ten equal parts and then to sight the correct location on the aircraft as it flew by. This resulted in a precision limit for Δh of ±3 feet (line 40 of table D2). The aircraft was assumed to be flying directly over the flyby line.

The bias and precision limits of the standard day temperature at the zero grid line pressure altitude, T_{aSD} (equation B43), were ±0.01 and ±0.02 degrees C, respectively. Although these uncertainties were negligible, they were carried through the analysis.

The propagation of bias and precision uncertainties through equations B44 through B50 are given in table D3 for each tower flyby test point. The uncertainty analysis for the instrument-corrected total and static pressures (equations B47 and B48) is given in table D1. The table shows that a maximum uncertainty of approximately ±13 feet of pressure altitude at 2,300 feet resulted from the tower flyby method. The static source error correction coefficients with error bars are plotted in figures D1 through D7. The uncertainties in the static source error correction coefficients and pressure altitude static source error corrections are plotted in figures D8 and D9.

Table D3 Uncertainties in Derived Parameters from the Tower Flyby Method

Date	Test Point	Instrument Corrected Pressure Altitude (ft)	Instrument Corrected Mach Number (n/d)	Indicated Angle of Attack (deg)	Static source error correction Coefficient (n/d)	Altitude Position Error Correction (ft)	Uncertainty in Difference in Pressure Altitude Between Tower and Aircraft, Equation B44		Uncertainty in Calibrated Pressure Altitude, H_c Equation B45	
							Bias (ft)	Precision (ft)	Bias (ft)	Precision (ft)
7-Apr-04	1	2243	0.4656	4.8	-0.0166	72	0.1	3.0	5.0	11.4
	2	2247	0.5130	4.2	-0.0168	90	0.1	3.0	5.0	11.4
	3	2241	0.5296	3.7	-0.0155	89	0.1	3.0	5.0	11.4
	4	2222	0.5926	2.9	-0.0138	101	0.1	3.0	5.0	11.4
	5	2205	0.6140	2.7	-0.0145	115	0.1	3.0	5.0	11.4
	6	2172	0.6573	2.4	-0.0132	121	0.0	3.0	5.0	11.4
	7	2174	0.6972	2.0	-0.0125	131	0.1	3.0	5.0	11.4
	8	2191	0.7862	1.5	-0.0092	126	0.1	3.0	5.0	11.4
	9	2192	0.7989	1.4	-0.0090	128	0.1	3.0	5.0	11.4
	10	2182	0.8672	1.2	-0.0068	118	0.1	3.0	5.0	11.4
	11	2163	0.8767	1.1	-0.0068	121	0.0	3.0	5.0	11.4
	12	2237	0.4202	5.2	-0.0176	62	0.1	3.0	5.0	11.4
	13	2235	0.3829	6.3	-0.0174	50	0.0	3.0	5.0	11.4
	14	2278	0.3086	9.4	-0.0171	32	0.1	3.0	5.0	11.4
	15	2299	0.2765	11.6	-0.0172	26	0.1	3.0	5.0	11.4
	16	2294	0.2869	10.7	-0.0204	33	0.1	3.0	5.0	11.4
	17	2252	0.3599	6.7	-0.0192	49	0.1	3.0	5.0	11.4
	18	2215	0.5108	3.1	-0.0155	83	0.1	3.0	5.0	11.4
	19	2160	0.7405	1.5	-0.0106	127	0.0	3.0	5.0	11.4

Table D3 Uncertainties in Derived Parameters from the Tower Flyby Method (Continued)

Date	Test Point	Instrument Corrected Pressure Altitude (ft)	Instrument Corrected Mach Number (n/d)	Indicated Angle of Attack (deg)	Static source error correction Coefficient (n/d)	Altitude Position Error Correction (ft)	Uncertainty in Difference in Pressure Altitude Between Tower and Aircraft, Equation B44		Uncertainty in Calibrated Pressure Altitude, H_c Equation B45	
							Bias (ft)	Precision (ft)	Bias (ft)	Precision (ft)
12-Apr-04	20	2140	0.4696	5.3	-0.0174	78	0.0	3.0	5.0	6.7
	21	2131	0.5092	3.8	-0.0156	83	0.0	3.0	5.0	6.7
	22	2128	0.5440	3.5	-0.0154	94	0.0	3.0	5.0	6.7
	23	2107	0.5825	2.9	-0.0145	102	0.0	3.0	5.0	6.7
	24	2118	0.6186	2.5	-0.0140	113	0.0	3.0	5.0	6.7
	25	2109	0.6625	2.1	-0.0122	114	0.0	3.0	5.0	6.7
	26	2117	0.6951	1.8	-0.0117	122	0.0	3.0	5.0	6.7
	27	2104	0.7372	1.5	-0.0107	128	0.0	3.0	5.0	6.7
	28	2108	0.7742	1.4	-0.0097	130	0.0	3.0	5.0	6.7
	29	2115	0.8150	1.2	-0.0081	122	0.0	3.0	5.0	6.7
12-Apr-04	30	2113	0.8519	1.0	-0.0072	120	0.0	3.0	5.0	6.7
	31	2115	0.8979	1.0	-0.0063	118	0.0	3.0	5.0	6.7
	32	2147	0.4316	4.7	-0.0168	63	0.0	3.0	5.0	6.7
	33	2178	0.3936	5.6	-0.0172	53	0.0	3.0	5.0	6.7
	34	2178	0.3535	6.9	-0.0163	40	0.0	3.0	5.0	6.7
	35	2199	0.3141	8.3	-0.0190	37	0.1	3.0	5.0	6.7
	36	2195	0.2966	9.3	-0.0157	27	0.0	3.0	5.0	6.7
	37	2196	0.2845	9.7	-0.0161	25	0.0	3.0	5.0	6.7
	38	2131	0.4694	3.5	-0.0167	74	0.0	3.0	5.0	6.7
	39	2188	0.2820	9.6	-0.0166	26	0.0	3.0	5.0	6.7
	40	2207	0.2708	10.1	-0.0147	21	0.0	3.0	5.0	6.7

Table D3 Uncertainties in Derived Parameters from the Tower Flyby Method (Continued)

Date	Test Point	Instrument Corrected Pressure Altitude (ft)	Instrument Corrected Mach Number (n/d)	Indicated Angle of Attack (deg)	Static source error correction Coefficient (n/d)	Altitude Position Error Correction (ft)	Uncertainty in Difference in Pressure Altitude Between Tower and Aircraft, Equation B44		Uncertainty in Calibrated Pressure Altitude, H_c Equation B45	
							Bias (ft)	Precision (ft)	Bias (ft)	Precision (ft)
13-Apr-04	41	2192	0.4760	4.7	-0.0162	74	0.0	3.0	5.0	5.0
	42	2184	0.5169	3.8	-0.0155	84	0.1	3.0	5.0	5.0
	43	2165	0.5696	3.1	-0.0148	100	0.0	3.0	5.0	5.0
	44	2166	0.5920	2.7	-0.0143	104	0.1	3.0	5.0	5.0
	45	2146	0.6409	2.4	-0.0132	115	0.0	3.0	5.0	5.0
	46	2139	0.6667	2.1	-0.0124	118	0.0	3.0	5.0	5.0
	47	2146	0.6919	2.0	-0.0122	126	0.1	3.0	5.0	5.0
	48	2140	0.7345	1.7	-0.0109	128	0.1	3.0	5.0	5.0
	49	2145	0.7769	1.3	-0.0096	129	0.1	3.0	5.0	5.0
	50	2138	0.8179	1.2	-0.0082	123	0.0	3.0	5.0	5.0
	51	2151	0.8621	1.1	-0.0068	116	0.1	3.0	5.0	5.0
	52	2131	0.9057	1.0	-0.0063	120	0.0	3.0	5.0	5.0
	53	2195	0.4312	4.6	-0.0168	62	0.0	3.0	5.0	5.0
	54	2199	0.3931	5.6	-0.0157	48	0.0	3.0	5.0	5.0
	55	2223	0.3519	7.0	-0.0187	46	0.1	3.0	5.0	5.0
	56	2227	0.3136	8.8	-0.0172	33	0.0	3.0	5.0	5.0
	57	2232	0.2855	10.0	-0.0172	27	0.0	3.0	5.0	5.0
	58	2237	0.2999	9.2	-0.0182	32	0.1	3.0	5.0	5.0

Table D3 Uncertainties in Derived Parameters from the Tower Flyby Method (Continued)

Date	Test Point	Instrument Corrected Pressure Altitude (ft)	Instrument Corrected Mach Number (n/d)	Indicated Angle of Attack (deg)	Static source error correction Coefficient (n/d)	Altitude Position Error Correction (ft)	Uncertainty in Difference in Pressure Altitude Between Tower and Aircraft, Equation B44		Uncertainty in Calibrated Pressure Altitude, H_c Equation B45	
							Bias (ft)	Precision (ft)	Bias (ft)	Precision (ft)
13-Apr-04	59	2191	0.4686	3.5	-0.0175	78	0.1	3.0	5.0	5.0
	60	2175	0.5087	2.9	-0.0160	84	0.0	3.0	5.0	5.0
	61	2193	0.4317	4.2	-0.0170	64	0.0	3.0	5.0	5.0
	62	2261	0.2713	10.7	-0.0165	24	0.1	3.0	5.0	5.0
	63	2136	0.7069	1.2	-0.0120	130	0.1	3.0	5.0	5.0
30-Apr-04	64	2113	0.4810	4.5	-0.0157	73	0.0	3.0	5.0	5.0
	65	2095	0.7761	1.5	-0.0092	123	0.1	3.1	5.0	5.0
	66	2150	0.3232	9.6	-0.0164	34	0.0	3.0	5.0	5.0
23-Nov-04	67	2164	0.5442	3.4	-0.0141	86	0.1	3.2	5.0	11.4
	68	2155	0.7021	1.6	-0.0107	114	0.1	3.2	5.0	11.5
	69	2160	0.8527	1.0	-0.0070	116	0.1	3.2	5.0	11.5
	70	2185	0.4730	4.3	-0.0149	67	0.1	3.2	5.0	11.4
	71	2245	0.3105	9.2	-0.0206	39	0.1	3.2	5.0	11.5
	72	2238	0.2872	10.7	-0.0151	24	0.1	3.2	5.0	11.5
	73	2211	0.3933	5.5	-0.0184	57	0.1	3.2	5.0	11.4
	74	2144	0.6304	1.9	-0.0136	114	0.1	3.2	5.0	11.4
	75	2127	0.9078	1.3	-0.0061	117	0.1	3.1	5.0	11.4
	76	2165	0.5492	2.5	-0.0143	89	0.1	3.1	5.0	11.4
	77	2140	0.6201	1.8	-0.0135	110	0.1	3.1	5.0	11.4
	78	2132	0.7016	1.3	-0.0110	117	0.1	3.1	5.0	11.4
	79	2134	0.7719	0.9	-0.0095	125	0.1	3.1	5.0	11.4
	80	2124	0.8117	0.8	-0.0084	124	0.1	3.1	5.0	11.4

Table D3 Uncertainties in Derived Parameters from the Tower Flyby Method (Continued)

Date	Test Point	Uncertainty in Instrument-Corrected Pressure Altitude, H_{ic}		Uncertainty in Altitude Static Source Error Correction, $\Delta H_{pc} = H - H_{ic}$			Uncertainty in Ambient Air Pressure Equation B46		Uncertainty in Static source error correction Coefficient Equation B50			Percent Uncertainty
		Bias (in Hg)	Precision (in Hg)	Bias (n/d)	Precision (n/d)	**Total (n/d)**	Bias (n/d)	Precision (n/d)	Bias (n/d)	Precision (n/d)	**Total (n/d)**	(n/d)
7-Apr-04	1	2.3	2.3	5.5	11.6	**12.9**	0.005	0.012	0.0013	0.0027	**0.0029**	17.8
	2	2.3	2.3	5.5	11.6	**12.9**	0.005	0.012	0.0010	0.0022	**0.0024**	14.3
	3	2.3	2.3	5.5	11.6	**12.9**	0.005	0.012	0.0010	0.0020	**0.0022**	14.5
	4	2.3	2.3	5.5	11.6	**12.9**	0.005	0.012	0.0008	0.0016	**0.0018**	12.7
	5	2.3	2.3	5.5	11.6	**12.9**	0.005	0.012	0.0007	0.0015	**0.0016**	11.2
	6	2.3	2.3	5.5	11.6	**12.9**	0.005	0.012	0.0006	0.0013	**0.0014**	10.6
	7	2.3	2.3	5.5	11.6	**12.9**	0.005	0.012	0.0005	0.0011	**0.0012**	9.8
	8	2.3	2.3	5.5	11.6	**12.9**	0.005	0.012	0.0004	0.0008	**0.0009**	10.2
	9	2.3	2.3	5.5	11.6	**12.9**	0.005	0.012	0.0004	0.0008	**0.0009**	10.0
	10	2.3	2.3	5.5	11.6	**12.9**	0.005	0.012	0.0003	0.0007	**0.0007**	10.9
	11	2.3	2.3	5.5	11.6	**12.9**	0.005	0.012	0.0003	0.0007	**0.0007**	10.6
	12	2.3	2.3	5.5	11.6	**12.9**	0.005	0.012	0.0016	0.0033	**0.0037**	20.8
	13	2.3	2.3	5.5	11.6	**12.9**	0.005	0.012	0.0019	0.0040	**0.0044**	25.5
	14	2.3	2.3	5.5	11.6	**12.9**	0.005	0.012	0.0030	0.0063	**0.0069**	40.4
	15	2.3	2.3	5.5	11.6	**12.9**	0.005	0.012	0.0037	0.0078	**0.0087**	50.4
	16	2.3	2.3	5.5	11.6	**12.9**	0.005	0.012	0.0034	0.0073	**0.0080**	39.3
	17	2.3	2.3	5.5	11.6	**12.8**	0.005	0.012	0.0022	0.0046	**0.0050**	26.3
	18	2.3	2.3	5.5	11.6	**12.8**	0.005	0.012	0.0010	0.0022	**0.0024**	15.6
	19	2.3	2.3	5.5	11.6	**12.8**	0.005	0.012	0.0005	0.0010	**0.0011**	10.1

Table D3 Uncertainties in Derived Parameters from the Tower Flyby Method (Continued)

		Uncertainty in Instrument-Corrected Pressure Altitude, H_{ic}		Uncertainty in Altitude Static Source Error Correction, $\Delta H_{pc} = H - H_{ic}$			Uncertainty in Ambient Air Pressure Equation B46		Uncertainty in Static source error correction Coefficient Equation B50			Percent Uncertainty
Date	Test Point	Bias (in Hg)	Precision (in Hg)	Bias (n/d)	Precision (n/d)	**Total (n/d)**	Bias (n/d)	Precision (n/d)	Bias (n/d)	Precision (n/d)	**Total (n/d)**	(n/d)
12-Apr-04	20	2.3	2.3	5.5	7.1	**9.0**	0.005	0.007	0.0012	0.0016	**0.0020**	11.6
	21	2.3	2.3	5.5	7.1	**9.0**	0.005	0.007	0.0010	0.0013	**0.0017**	10.9
	22	2.3	2.3	5.5	7.1	**9.0**	0.005	0.007	0.0009	0.0012	**0.0015**	9.6
	23	2.3	2.3	5.5	7.1	**9.0**	0.005	0.007	0.0008	0.0010	**0.0013**	8.8
	24	2.3	2.3	5.5	7.1	**9.0**	0.005	0.007	0.0007	0.0009	**0.0011**	8.0
	25	2.3	2.3	5.5	7.1	**9.0**	0.005	0.007	0.0006	0.0008	**0.0010**	7.8
	26	2.3	2.3	5.5	7.1	**9.0**	0.005	0.007	0.0005	0.0007	**0.0009**	7.3
	27	2.3	2.3	5.5	7.1	**9.0**	0.005	0.007	0.0005	0.0006	**0.0008**	7.0
	28	2.3	2.3	5.5	7.1	**9.0**	0.005	0.007	0.0004	0.0005	**0.0007**	6.9
	29	2.3	2.3	5.5	7.1	**9.0**	0.005	0.007	0.0004	0.0005	**0.0006**	7.4
	30	2.3	2.3	5.5	7.1	**9.0**	0.005	0.007	0.0003	0.0004	**0.0005**	7.5
12-Apr-04	31	2.3	2.3	5.5	7.1	**9.0**	0.005	0.007	0.0003	0.0004	**0.0005**	7.6
	32	2.3	2.3	5.5	7.1	**9.0**	0.005	0.007	0.0015	0.0019	**0.0024**	14.3
	33	2.3	2.3	5.5	7.1	**9.0**	0.005	0.007	0.0018	0.0023	**0.0029**	17.0
	34	2.3	2.3	5.5	7.1	**9.0**	0.005	0.007	0.0022	0.0029	**0.0036**	22.4
	35	2.3	2.3	5.5	7.1	**9.0**	0.005	0.007	0.0029	0.0037	**0.0047**	24.5
	36	2.3	2.3	5.5	7.1	**9.0**	0.005	0.007	0.0032	0.0041	**0.0052**	33.2
	37	2.3	2.3	5.5	7.1	**9.0**	0.005	0.007	0.0035	0.0045	**0.0057**	35.4
	38	2.3	2.3	5.5	7.1	**9.0**	0.005	0.007	0.0012	0.0016	**0.0020**	12.1
	39	2.3	2.3	5.5	7.1	**9.0**	0.005	0.007	0.0036	0.0046	**0.0058**	34.9
	40	2.3	2.3	5.5	7.1	**9.0**	0.005	0.007	0.0039	0.0050	**0.0063**	43.0

Table D3 Uncertainties in Derived Parameters from the Tower Flyby Method (Continued)

		Uncertainty in Instrument-Corrected Pressure Altitude, H_{ic}		Uncertainty in Altitude Static Source Error Correction, $\Delta H_{pc} = H - H_{ic}$			Uncertainty in Ambient Air Pressure Equation B46		Uncertainty in Static source error correction Coefficient Equation B50			Percent Uncertainty
Date	Test Point	Bias (in Hg)	Precision (in Hg)	Bias (n/d)	Precision (n/d)	**Total (n/d)**	Bias (n/d)	Precision (n/d)	Bias (n/d)	Precision (n/d)	**Total (n/d)**	(n/d)
13-Apr-04	41	2.3	2.3	5.5	5.5	**7.8**	0.005	0.005	0.0012	0.0012	**0.0017**	10.5
	42	2.3	2.3	5.5	5.5	**7.8**	0.005	0.005	0.0010	0.0010	**0.0014**	9.2
	43	2.3	2.3	5.5	5.5	**7.8**	0.005	0.005	0.0008	0.0008	**0.0012**	7.8
	44	2.3	2.3	5.5	5.5	**7.8**	0.005	0.005	0.0008	0.0008	**0.0011**	7.5
	45	2.3	2.3	5.5	5.5	**7.8**	0.005	0.005	0.0006	0.0006	**0.0009**	6.8
	46	2.3	2.3	5.5	5.5	**7.8**	0.005	0.005	0.0006	0.0006	**0.0008**	6.6
	47	2.3	2.3	5.5	5.5	**7.8**	0.005	0.005	0.0005	0.0005	**0.0008**	6.2
	48	2.3	2.3	5.5	5.5	**7.8**	0.005	0.005	0.0005	0.0005	**0.0007**	6.1
	49	2.3	2.3	5.5	5.5	**7.8**	0.005	0.005	0.0004	0.0004	**0.0006**	6.0
	50	2.3	2.3	5.5	5.5	**7.8**	0.005	0.005	0.0004	0.0004	**0.0005**	6.3
	51	2.3	2.3	5.5	5.5	**7.8**	0.005	0.005	0.0003	0.0003	**0.0005**	6.7
	52	2.3	2.3	5.5	5.5	**7.7**	0.005	0.005	0.0003	0.0003	**0.0004**	6.5
	53	2.3	2.3	5.5	5.5	**7.8**	0.005	0.005	0.0015	0.0015	**0.0021**	12.5
	54	2.3	2.3	5.5	5.5	**7.8**	0.005	0.005	0.0018	0.0018	**0.0025**	16.1
	55	2.3	2.3	5.5	5.5	**7.8**	0.005	0.005	0.0023	0.0023	**0.0032**	17.0
	56	2.3	2.3	5.5	5.5	**7.8**	0.005	0.005	0.0029	0.0029	**0.0040**	23.5
	57	2.3	2.3	5.5	5.5	**7.8**	0.005	0.005	0.0035	0.0035	**0.0049**	28.6
	58	2.3	2.3	5.5	5.5	**7.8**	0.005	0.005	0.0031	0.0031	**0.0044**	24.4
	59	2.3	2.3	5.5	5.5	**7.7**	0.005	0.005	0.0012	0.0012	**0.0018**	10.0
	60	2.3	2.3	5.5	5.5	**7.7**	0.005	0.005	0.0010	0.0010	**0.0015**	9.2

Table D3 Uncertainties in Derived Parameters from the Tower Flyby Method (Concluded)

		Uncertainty in Instrument-Corrected Pressure Altitude, H_{ic}		Uncertainty in Altitude Static Source Error Correction, $\Delta H_{pc} = H - H_{ic}$			Uncertainty in Ambient Air Pressure Equation B46		Uncertainty in Static source error correction Coefficient Equation B50			Percent Uncertainty
Date	Test Point	Bias (in Hg)	Precision (in Hg)	Bias (n/d)	Precision (n/d)	**Total (n/d)**	Bias (n/d)	Precision (n/d)	Bias (n/d)	Precision (n/d)	**Total (n/d)**	(n/d)
13-Apr-04	61	2.3	2.3	5.5	5.5	**7.7**	0.005	0.005	0.0015	0.0015	**0.0021**	12.2
	62	2.3	2.3	5.5	5.5	**7.8**	0.005	0.005	0.0039	0.0038	**0.0054**	33.0
	63	2.3	2.3	5.5	5.5	**7.7**	0.005	0.005	0.0005	0.0005	**0.0007**	6.0
30-Apr-04	64	2.3	2.3	5.5	5.5	**7.8**	0.005	0.005	0.0012	0.0012	**0.0017**	10.6
	65	2.3	2.3	5.5	5.5	**7.8**	0.005	0.005	0.0004	0.0004	**0.0006**	6.4
	66	2.3	2.3	5.5	5.5	**7.8**	0.005	0.005	0.0027	0.0027	**0.0038**	23.2
23-Nov-04	67	2.3	2.3	5.5	11.7	**12.9**	0.005	0.012	0.0009	0.0019	**0.0021**	15.0
	68	2.3	2.3	5.5	11.7	**12.9**	0.005	0.012	0.0005	0.0011	**0.0012**	11.3
	69	2.3	2.3	5.5	11.7	**12.9**	0.005	0.012	0.0003	0.0007	**0.0008**	11.1
	70	2.3	2.3	5.5	11.7	**12.9**	0.005	0.012	0.0012	0.0026	**0.0029**	19.2
	71	2.3	2.3	5.5	11.7	**12.9**	0.005	0.012	0.0029	0.0062	**0.0069**	33.3
	72	2.3	2.3	5.5	11.7	**12.9**	0.005	0.012	0.0034	0.0073	**0.0080**	53.1
	73	2.3	2.3	5.5	11.7	**12.9**	0.005	0.012	0.0018	0.0038	**0.0042**	22.8
	74	2.3	2.3	5.5	11.7	**12.9**	0.005	0.012	0.0007	0.0014	**0.0015**	11.3
	75	2.3	2.3	5.5	11.7	**12.9**	0.005	0.012	0.0003	0.0006	**0.0007**	11.0
	76	2.3	2.3	5.5	11.7	**12.9**	0.005	0.012	0.0009	0.0019	**0.0021**	14.5
	77	2.3	2.3	5.5	11.7	**12.9**	0.005	0.012	0.0007	0.0014	**0.0016**	11.8
	78	2.3	2.3	5.5	11.7	**12.9**	0.005	0.012	0.0005	0.0011	**0.0012**	11.0
	79	2.3	2.3	5.5	11.7	**12.9**	0.005	0.012	0.0004	0.0009	**0.0010**	10.3
	80	2.3	2.3	5.5	11.7	**12.9**	0.005	0.012	0.0004	0.0008	**0.0009**	10.4

Note: 1. The Percent Uncertainty was equal to the total uncertainty in static source error correction coefficient divided by the static source error correction coefficient times 100.

Uncertainty in Formation Flight with Trailing Cone-Equipped Aircraft Method:

The static source error corrections were determined from formation flight with a C-17A aircraft equipped with a trailing cone using the data analysis methods in appendix B.

The uncertainties in instrument-corrected total and static pressure were estimated earlier (see table D1). These uncertainties were propagated through equation B55 and the results are listed in tables D4 and D5.

Rather than propagate the elemental uncertainties through equations B56 through B58 and B60, constant uncertainties in ambient air temperature of 0 degrees C (bias limit) and 2.4 degrees C (precision limit) were assumed.

The uncertainty in the pitch corrections to the C-17A aircraft GPS altitude (equation B59) was estimated by assuming that the moment arms between the differential global positioning system (DGPS) antenna and the trailing cone pressure transducer were exact and that the uncertainty was due to uncertainty in the C-17A aircraft pitch angle. The uncertainty in the C-17A aircraft pitch angles was estimated by assuming that the bias limit was equal to the average difference between the two pitch angles used for this analysis. Those pitch angles were measured by C-17A aircraft inertial reference unit numbers 1 and 4, and the bias limit was approximately ±0.02 degrees. The precision index of the C-17A aircraft pitch angles was assumed to be equal to the average of the standard deviations of each of the test points, which was 0.04 degrees. The precision limit was equal to the Student's *t* statistic times the precision index, or 2×0.04 equaled ±0.08 degrees. When these limits were propagated through equation B59, the combined uncertainty in the result was approximately ±2 feet for the March 2005 data (table D5) and ±6 feet for the December 2004 data (table D4). The uncertainties were different between the December 2004 and March 2005 missions because the December mission used the production C-17A aircraft GPS receiver and the March mission used the G-Lite DGPS receiver. The production GPS receiver was located in the forward section of the fuselage and therefore had a longer moment arm than the G-Lite, whose antenna was located just aft of the wing.

The uncertainty in the Advanced Range Data System (ARDS) pod DGPS altitude was specified by the Air Force Flight Test Center (AFFTC) range squadron (412TW/ENRCT) as ±10 feet. The uncertainty in the C-17A aircraft G-Lite DGPS altitude, also specified by 412TW/ENRCT, was ±1.5 feet (used for the March 2005 mission). The uncertainty in the C-17A aircraft production GPS altitude (used for the December 2004 mission) was assumed to equal ±30 feet. These values were treated as bias limits.

The specified accuracy of the C-17A aircraft trailing cone pressure transducer was 0.015 percent of the full scale reading, or about 0.006 inches of mercury.

The bias and precision limits were calculated for equations B60 through B65 and the results are listed in table D4 for the December 2004 mission and in table D5 for the March 2005 mission. The total uncertainties in the altitude static source error corrections are summarized in table D6. Note that the average total uncertainty in the static source error corrections for the December 2004 mission was larger than the uncertainty for the March 2005 mission. This was due to using the C-17A aircraft production GPS, which had a much larger uncertainty than the G-lite DGPS altitude, to correct for formation errors during the December mission.

Table D4 Uncertainties in Derived Parameters from the Trailing Cone Method - December 2004

Number	Instrument Corrected Mach Number (n/d)	Indicated Angle of Attack (deg)	Instrument Corrected Pressure Altitude (ft)	Static source error correction Coefficient (n/d)	Altitude Position Error Correction (ft)	Uncertainty in Instrument-Corrected Pressure Altitude, H_{ic} Equation B53		Uncertainty in C-17 Pitch Correction, Equation B59		Uncertainty in GPS Correction, ΔH_{GPS} Equation B60	
						Bias (ft)	Precision (ft)	Bias (ft)	Precision (ft)	Bias (ft)	Precision (ft)
1	0.7745	5.4	35,684	-0.0079	80	7.1	7.1	1.5	5.9	31.0	5.7
2	0.8091	4.4	34,068	-0.0066	75	6.6	6.6	1.5	5.9	30.9	5.7
3	0.7939	4.6	34,081	-0.0072	78	6.6	6.6	1.5	5.9	30.9	5.7
4	0.7737	4.9	34,080	-0.0082	85	6.6	6.6	1.5	5.9	30.9	5.7
5	0.7528	5.3	34,083	-0.0079	77	6.6	6.6	1.5	5.9	31.0	5.7
6	0.7357	5.5	34,075	-0.0092	84	6.6	6.6	1.5	5.9	30.9	5.7
7	0.7348	5.6	34,075	-0.0095	87	6.6	6.6	1.5	5.9	30.9	5.7
8	0.7129	5.9	34,068	-0.0109	94	6.6	6.6	1.5	5.9	30.9	5.7
9	0.7107	5.9	34,070	-0.0108	92	6.6	6.6	1.5	5.9	30.9	5.7
10	0.6915	6.2	34,066	-0.0117	94	6.6	6.6	1.5	5.9	30.9	5.7
11	0.6743	6.5	34,060	-0.0122	92	6.6	6.6	1.5	5.9	30.9	5.7
12	0.8147	4.4	32,894	-0.0060	70	6.3	6.3	1.5	5.9	28.4	5.2
13	0.8134	4.3	32,888	-0.0068	79	6.3	6.3	1.5	5.9	28.4	5.2
14	0.8036	4.5	32,869	-0.0076	86	6.3	6.3	1.5	5.9	28.4	5.2

Table D5 Uncertainties in Derived Parameters from the Trailing Cone Method - March 2004

Number	Instrument Corrected Mach Number (n/d)	Indicated Angle of Attack (deg)	Instrument Corrected Pressure Altitude (ft)	Static source error correction Coefficient (n/d)	Altitude Position Error Correction (ft)	Uncertainty in Instrument-Corrected Pressure Altitude, H_{ic} Equation B53		Uncertainty in C-17 Pitch Correction, Equation B59		Uncertainty in GPS Correction, ΔH_{GPS} Equation B60	
						Bias (ft)	Precision (ft)	Bias (ft)	Precision (ft)	Bias (ft)	Precision (ft)
1	0.3684	8.0	9,941	-0.0147	37	2.9	2.9	0.5	2.2	9.9	2.1
2	0.4477	5.2	9,928	-0.0160	61	2.9	2.9	0.5	2.1	9.9	2.1
3	0.4948	4.2	9,923	-0.0149	70	2.9	2.9	0.5	2.1	9.9	2.1
4	0.5956	2.7	9,924	-0.0128	90	2.9	2.9	0.5	2.1	9.9	2.0
5	0.5961	2.7	9,910	-0.0125	88	2.9	2.9	0.5	2.1	9.9	2.0
6	0.6214	2.5	9,918	-0.0121	93	2.9	2.9	0.5	2.1	9.9	2.0
7	0.4965	6.6	19,939	-0.0145	63	4.0	4.0	0.5	2.1	9.9	2.1
8	0.5969	4.4	19,928	-0.0123	80	4.0	4.0	0.5	2.1	9.9	2.1
9	0.6445	3.6	19,925	-0.0114	88	4.0	4.0	0.5	2.1	9.9	2.1
10	0.6959	3.0	19,940	-0.0095	87	4.0	4.0	0.5	2.1	9.9	2.1
11	0.7458	2.5	19,936	-0.0081	87	4.0	4.0	0.5	2.1	9.9	2.1
12	0.5956	7.2	29,907	-0.0098	58	5.7	5.7	0.5	2.1	10.1	2.1
13	0.6470	6.0	29,900	-0.0093	67	5.7	5.7	0.5	2.1	10.1	2.1
14	0.6965	5.0	29,908	-0.0085	72	5.7	5.7	0.5	2.1	10.1	2.1
15	0.7459	4.2	29,908	-0.0071	70	5.7	5.7	0.5	2.1	10.1	2.1
16	0.7954	3.6	29,910	-0.0053	60	5.7	5.7	0.5	2.1	10.0	2.1
17	0.6106	9.2	34,897	-0.0096	58	6.8	6.8	0.5	2.2	10.1	2.2
18	0.6463	8.1	34,899	-0.0082	56	6.8	6.8	0.5	2.1	10.1	2.1
19	0.6973	6.8	34,902	-0.0076	62	6.8	6.8	0.5	2.1	10.1	2.1
20	0.7467	5.8	34,914	-0.0065	61	6.8	6.8	0.5	2.1	10.1	2.1
21	0.7965	4.8	34,908	-0.0048	52	6.8	6.8	0.5	2.1	10.1	2.1
22	0.6957	9.0	39,899	-0.0070	56	8.3	8.3	0.5	2.2	9.9	2.1
23	0.7157	8.4	39,903	-0.0066	56	8.3	8.3	0.5	2.1	9.9	2.1
24	0.7462	7.5	39,910	-0.0050	47	8.3	8.3	0.5	2.1	9.9	2.1

Table D5 Uncertainties in Derived Parameters from the Trailing Cone Method - March 2004 (Concluded)

	Uncertainty in Calibrated Pressure Altitude from the C-17, H_{cone}		Uncertainty in Altitude Position Error Correction, $\Delta H_{pc} = H_{cone} - (H_{ic} + \Delta H_{GPS})$			Uncertainty in GPS-Corrected Static Pressure, Equation B58		Uncertainty in Static source error correction Coefficient Equation B62			
Number	Bias (ft)	Precision (ft)	Bias (ft)	Precision (ft)	**Total (ft)**	Bias (in Hg)	Precision (in Hg)	Bias (n/d)	Precision (n/d)	**Total (n/d)**	Percent (n/d)
1	7.5	0.0	12.7	3.6	**13.2**	0.0082	0.0029	0.0051	0.0014	**0.0053**	35.7
2	7.5	0.0	12.7	3.5	**13.2**	0.0082	0.0028	0.0034	0.0009	**0.0035**	21.9
3	7.5	0.0	12.7	3.5	**13.2**	0.0082	0.0028	0.0027	0.0008	**0.0028**	19.0
4	7.5	0.0	12.7	3.5	**13.2**	0.0082	0.0028	0.0018	0.0005	**0.0019**	14.9
5	7.5	0.0	12.7	3.5	**13.2**	0.0082	0.0028	0.0018	0.0005	**0.0019**	15.2
6	7.5	0.0	12.7	3.5	**13.2**	0.0082	0.0028	0.0017	0.0005	**0.0017**	14.4
7	10.4	0.0	15.0	4.5	**15.6**	0.0062	0.0026	0.0034	0.0010	**0.0036**	24.8
8	10.4	0.0	14.9	4.5	**15.6**	0.0062	0.0026	0.0023	0.0007	**0.0024**	19.5
9	10.4	0.0	14.9	4.5	**15.6**	0.0062	0.0026	0.0019	0.0006	**0.0020**	17.8
10	10.4	0.0	14.9	4.5	**15.6**	0.0062	0.0026	0.0016	0.0005	**0.0017**	18.0
11	10.4	0.0	15.0	4.5	**15.6**	0.0062	0.0026	0.0014	0.0004	**0.0015**	18.1
12	14.8	0.0	18.8	6.1	**19.8**	0.0047	0.0025	0.0032	0.0010	**0.0033**	34.0
13	14.8	0.0	18.8	6.1	**19.8**	0.0047	0.0025	0.0026	0.0009	**0.0028**	29.8
14	14.8	0.0	18.8	6.0	**19.7**	0.0047	0.0025	0.0022	0.0007	**0.0023**	27.5
15	14.8	0.0	18.8	6.0	**19.7**	0.0047	0.0025	0.0019	0.0006	**0.0020**	28.2
16	14.8	0.0	18.8	6.0	**19.7**	0.0047	0.0025	0.0017	0.0005	**0.0017**	32.8
17	17.9	0.0	21.7	7.2	**22.9**	0.0041	0.0024	0.0036	0.0012	**0.0038**	39.7
18	17.9	0.0	21.7	7.2	**22.9**	0.0041	0.0024	0.0032	0.0011	**0.0033**	41.0
19	17.9	0.0	21.7	7.2	**22.8**	0.0041	0.0024	0.0027	0.0009	**0.0028**	37.0
20	17.9	0.0	21.7	7.2	**22.9**	0.0041	0.0024	0.0023	0.0008	**0.0024**	37.4
21	17.9	0.0	21.7	7.2	**22.8**	0.0041	0.0024	0.0020	0.0007	**0.0021**	43.8
22	22.6	0.0	26.0	8.6	**27.4**	0.0036	0.0024	0.0033	0.0011	**0.0035**	49.4
23	22.6	0.0	26.0	8.6	**27.4**	0.0036	0.0024	0.0031	0.0011	**0.0033**	49.2
24	22.6	0.0	26.0	8.6	**27.4**	0.0036	0.0024	0.0028	0.0010	**0.0030**	58.9

Note: The Percent Uncertainty was equal to the total uncertainty in static source error correction coefficient divided by the static source error correction coefficient times 100

Table D6 Summary of Uncertainties from the F-16B/C-17 Trailing Cone Formation Test Points

Flight Date	Pressure Altitude (1,000 ft)	Average Total Uncertainty in Static Source Error Corrections (±) Altitude (ft)
March 2005	10	13
March 2005	20	16
March 2005	30	20
March 2005	35	23
December 2004	35	37
March 2005	40	27

Notes: 1. The March 2005 mission used the G-Lite DGPS onboard the C-17 to correct for formation errors.
2. The December 2004 mission used the production C-17 GPS receiver to correct for formation errors.
3. The average uncertainties were calculated from the data in tables D4 and D5.

The static source error correction coefficient and altitude static source error corrections with error bars are plotted in figures D1 through D7. The uncertainties in the Mach number and pressure altitude static source error corrections are plotted in figures D8 and D9.

Uncertainty in Final Pacer Air Data:

The uncertainty in the final pacer air data was estimated by propagating the elemental uncertainties through equations B1 through B18. A summary of the total predicted uncertainties in calibrated Mach number, calibrated pressure altitude, and calibrated airspeed is tabulated in table D7 and plotted in figures D10 through D12. The maximum uncertainty was approximately ±30 feet and occurred at 40,000 feet pressure altitude. The uncertainties in calibrated Mach number and airspeed decreased as altitude decreased and Mach number increased. The uncertainties in calibrated pressure altitude decreased as altitude decreased and remained constant at each altitude as Mach number varied.

Table D7 Predicted Uncertainties in Pacer Air Data

Instrument-Corrected		Total Uncertainty (±)		
Pressure Altitude (ft)	Mach Number (n/d)	Calibrated Mach Number (n/d)	Calibrated Pressure Altitude (ft)	Calibrated Airspeed (kts)
2,300	0.30	0.0013	13	0.8
2,300	0.40	0.0010	13	0.6
2,300	0.50	0.0008	13	0.4
2,300	0.60	0.0007	13	0.4
2,300	0.70	0.0006	13	0.3
2,300	0.80	0.0005	13	0.2
2,300	0.90	0.0005	13	0.2
10,000	0.35	0.0013	14	0.7
10,000	0.40	0.0012	14	0.6
10,000	0.45	0.0010	14	0.5
10,000	0.50	0.0009	14	0.5
10,000	0.55	0.0008	14	0.4
10,000	0.60	0.0008	14	0.4
10,000	0.65	0.0007	14	0.3
10,000	0.70	0.0007	14	0.3
10,000	0.75	0.0006	14	0.3
10,000	0.80	0.0006	14	0.2
10,000	0.85	0.0005	14	0.2
10,000	0.90	0.0005	14	0.2
20,000	0.44	0.0014	17	0.6
20,000	0.50	0.0013	17	0.5
20,000	0.55	0.0011	17	0.5
20,000	0.60	0.0010	17	0.4
20,000	0.65	0.0010	17	0.4
20,000	0.70	0.0009	17	0.3
20,000	0.75	0.0008	17	0.3
20,000	0.80	0.0008	17	0.3
20,000	0.85	0.0007	17	0.3
20,000	0.90	0.0007	17	0.2
30,000	0.54	0.0016	21	0.6
30,000	0.60	0.0015	21	0.5
30,000	0.70	0.0013	21	0.4
30,000	0.80	0.0011	21	0.4
30,000	0.90	0.0011	21	0.3
35,000	0.60	0.0018	25	0.6
35,000	0.65	0.0017	25	0.5
35,000	0.70	0.0016	25	0.5
35,000	0.75	0.0015	25	0.4
35,000	0.80	0.0014	25	0.4
35,000	0.85	0.0013	25	0.4
35,000	0.90	0.0013	25	0.4
40,000	0.65	0.0021	30	0.6
40,000	0.70	0.0020	30	0.5
40,000	0.75	0.0018	30	0.5
40,000	0.80	0.0017	30	0.4
40,000	0.85	0.0016	30	0.4
40,000	0.90	0.0016	30	0.4

Uncertainty in Ambient Air Temperature:

The uncertainty in the ambient air temperatures was assumed to be a constant 2.4 degrees C. The production total temperature probe was evaluated during the tower flybys and the calculated ambient air temperatures had a precision index of 1.05 degrees C. For 13 degrees of freedom and 95 percent confidence, the Student's *t* statistic was 2.16. Thus the precision limit was equal to 2.16 times 1.05 degrees C. This precision limit was combined with the precision limit of ±0.7 degrees for the flyby tower zero grid line temperature and the result was ±2.4 degrees C.

LISTING OF SELECTED PARTIAL DERIVATIVES

A selection of some of the more complicated partial derivatives is listed below. These partial derivatives were used in equation D5 to propagate elemental uncertainties through to the final result.

Mach Number:

The partial derivatives of Mach number with respect to static and total pressure are listed below.

$$M = \left\{5\left[\left(\frac{P_t}{P_s}\right)^{2/7} - 1\right]\right\}^{1/2} \tag{D8}$$

$$\frac{\partial M}{\partial P_t} = \frac{\sqrt{5}}{7}\left[\left(\frac{P_t}{P_s}\right)^{2/7} - 1\right]^{-1/2} P_s^{-2/7} P_t^{-5/7} \tag{D9}$$

$$\frac{\partial M}{\partial P_s} = -\frac{\sqrt{5}}{7}\left[\left(\frac{P_t}{P_s}\right)^{2/7} - 1\right]^{-1/2} P_s^{-9/7} P_t^{2/7} \tag{D10}$$

Airspeed:

The derivative of airspeed with respect to compressible dynamic pressure is given below.

$$V = a_{\mathrm{SL}}\left\{5\left[\left(\frac{q_c}{P_{a\mathrm{SL}}}\right) + 1\right]^{2/7} - 1\right\}^{1/2} \tag{D11}$$

$$\frac{dV}{dq_c} = \frac{5}{7}\frac{a_{SL}}{P_{aSL}}\left\{5\left[\left(\frac{q_c}{P_{aSL}} + 1\right)^{2/7} - 1\right]\right\}^{-1/2}\left(\frac{q_c}{P_{aSL}} + 1\right)^{-5/7} \tag{D12}$$

Pressure Altitude:

The derivatives of pressure altitude with respect to static pressure are listed below for below and above 36,089 feet. If below 36,089 feet (or $\delta > 0.2234$), pressure altitude was:

$$H_{\text{c}} = -145442\left[\left(\frac{P_{\text{s}}}{P_{a_{\text{SL}}}}\right)^{0.190262} - 1\right] \qquad \text{(D13)}$$

$$\frac{dH}{dP_s} = -27{,}672 P_{aSL}^{-0.190262} P_s^{-0.809738} \qquad \text{(D14)}$$

Or, if above 36,089 feet (or $\delta < 0.2234$):

$$H_{\text{c}} = 36089.24 - 2.08057 \times 10^4 \ln\left(\frac{4.47708 P_{\text{s}}}{P_{a_{\text{SL}}}}\right) \qquad \text{(D15)}$$

$$\frac{dH}{dP_s} = -\frac{20805.7}{P_s} \qquad \text{(D16)}$$

Static Source Error Correction Coefficient:

The partial derivatives of the static source error correction coefficient, $CP_{\text{s}} = \Delta P_{\text{pc}}/q_{\text{cic}}$, are listed below.

$$CP_{\text{s}} = \frac{\Delta P_{\text{pc}}}{q_{\text{cic}}} = \frac{P_{\text{s}} - P_{\text{sic}}}{P_{\text{tic}} - P_{\text{sic}}} \qquad \text{(D17)}$$

$$\frac{\partial CP_{\text{s}}}{\partial P_{\text{s}}} = \frac{1}{P_{\text{tic}} - P_{\text{sic}}} \qquad \text{(D18)}$$

$$\frac{\partial CP_{\text{s}}}{\partial P_{\text{sic}}} = \frac{P_{\text{s}} - P_{\text{sic}}}{\left(P_{\text{tic}} - P_{\text{sic}}\right)^2} - \frac{1}{P_{\text{tic}} - P_{\text{sic}}} \qquad \text{(D19)}$$

$$\frac{\partial CP_{\text{s}}}{\partial P_{\text{tic}}} = \frac{P_{\text{sic}} - P_{\text{s}}}{\left(P_{\text{tic}} - P_{\text{sic}}\right)^2} \qquad \text{(D20)}$$

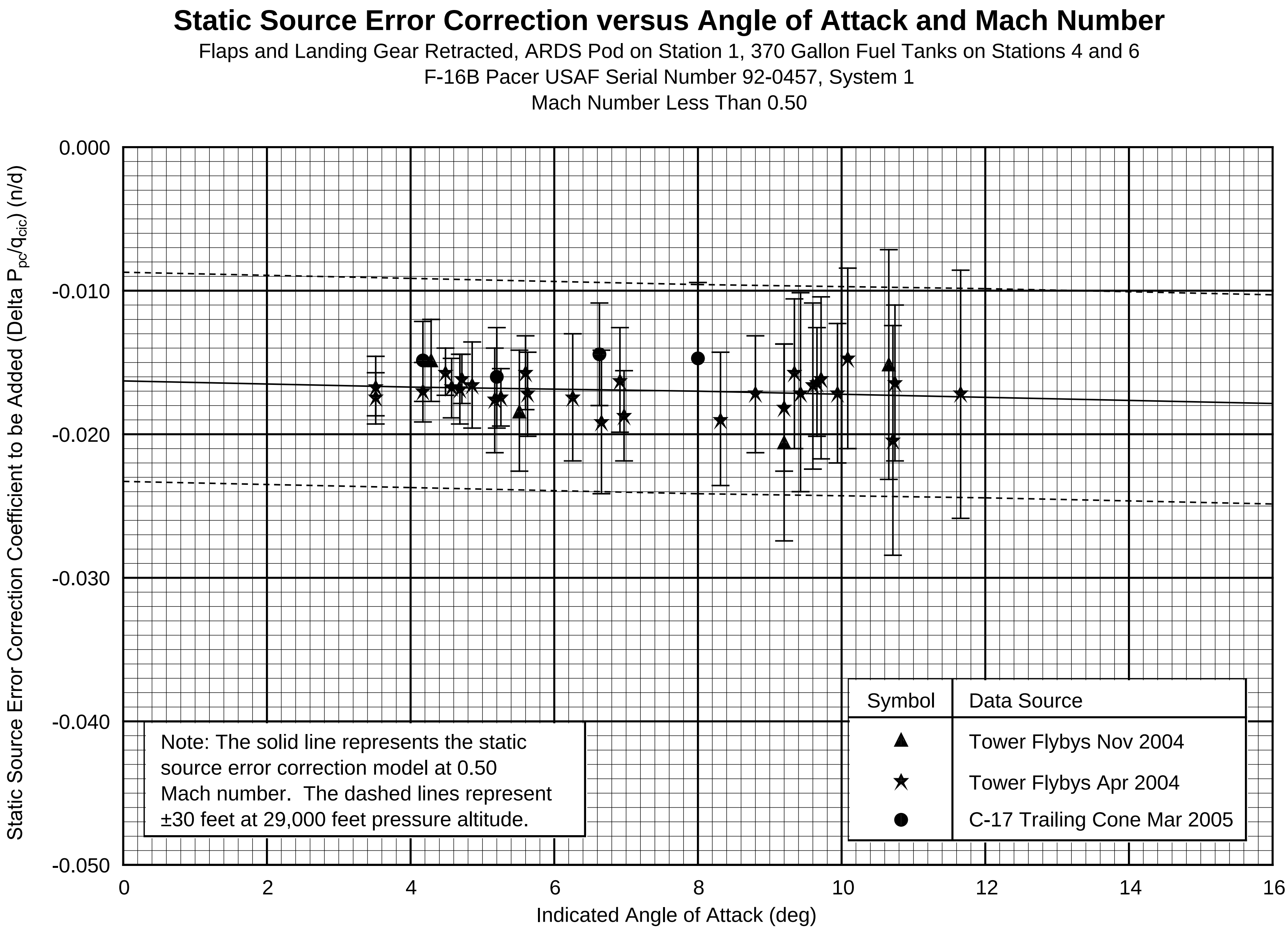

Figure D1 Static Source Error Corrections for Mach Numbers Less Than 0.50 - Uncertainty

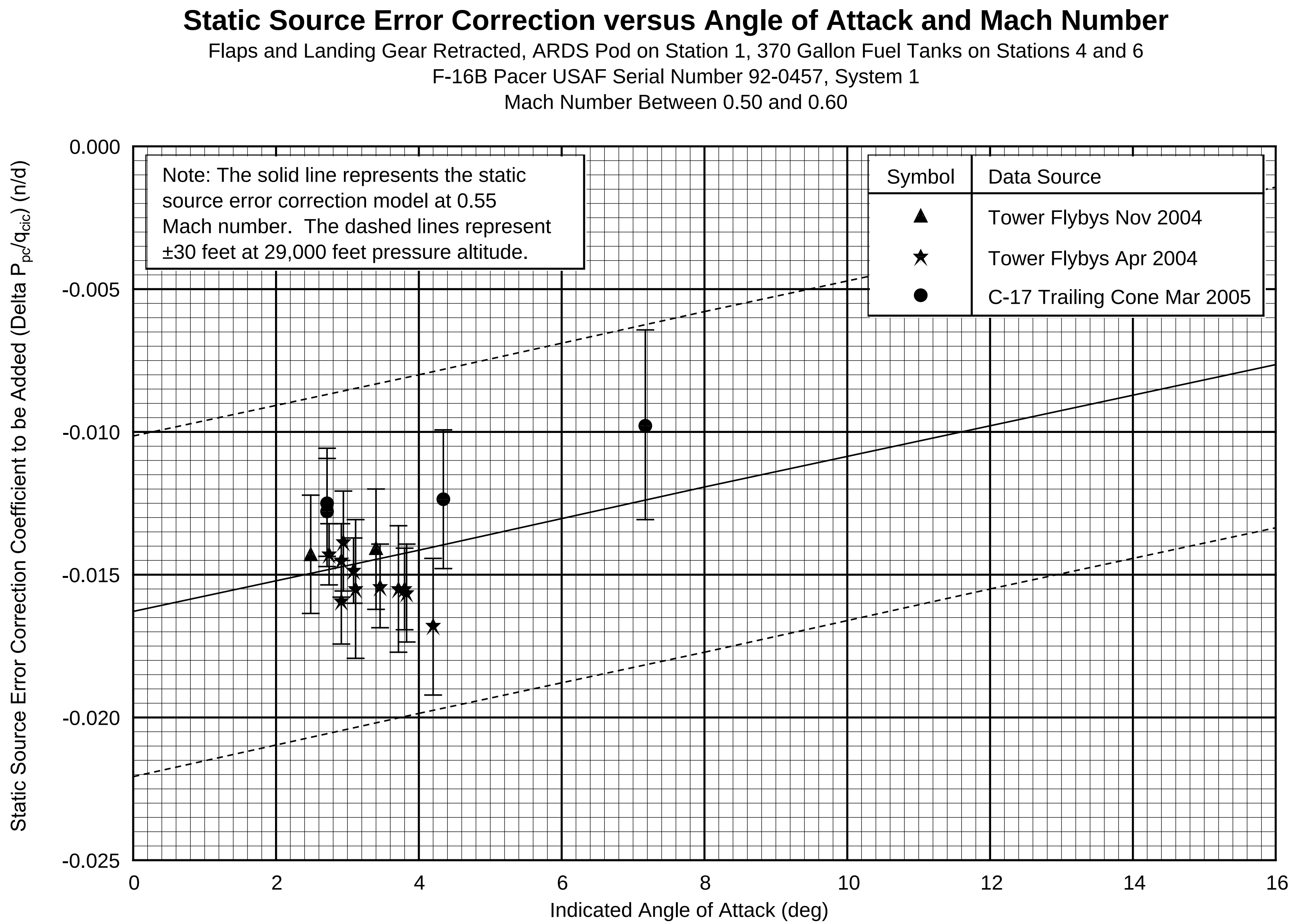

Figure D2 Static Source Error Corrections for Mach Numbers Between 0.50 and 0.60 - Uncertainty

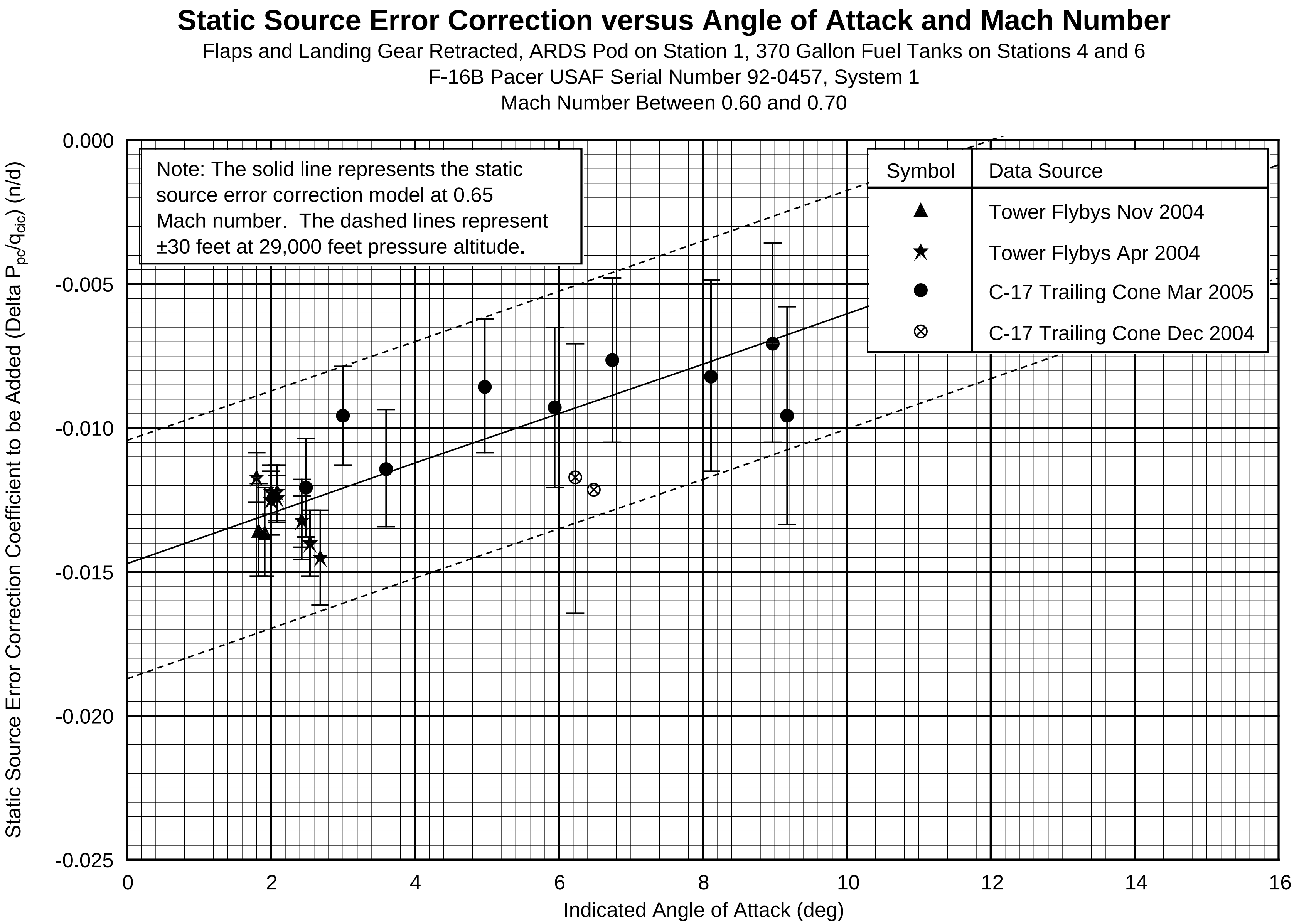

Figure D3 Static Source Error Corrections for Mach Numbers Between 0.60 and 0.70 - Uncertainty

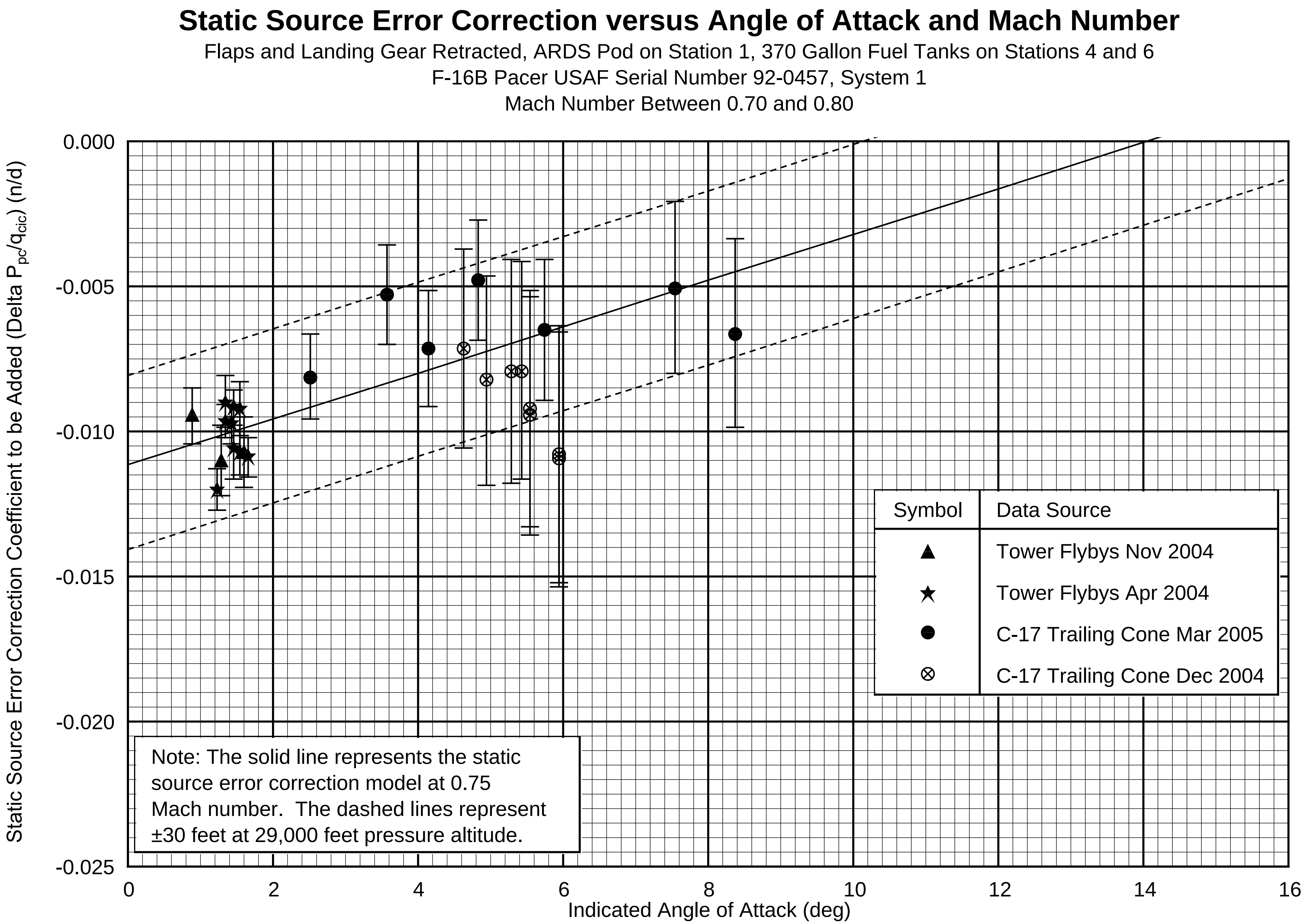

Figure D4 Static Source Error Corrections for Mach Numbers Between 0.70 and 0.80 - Uncertainty

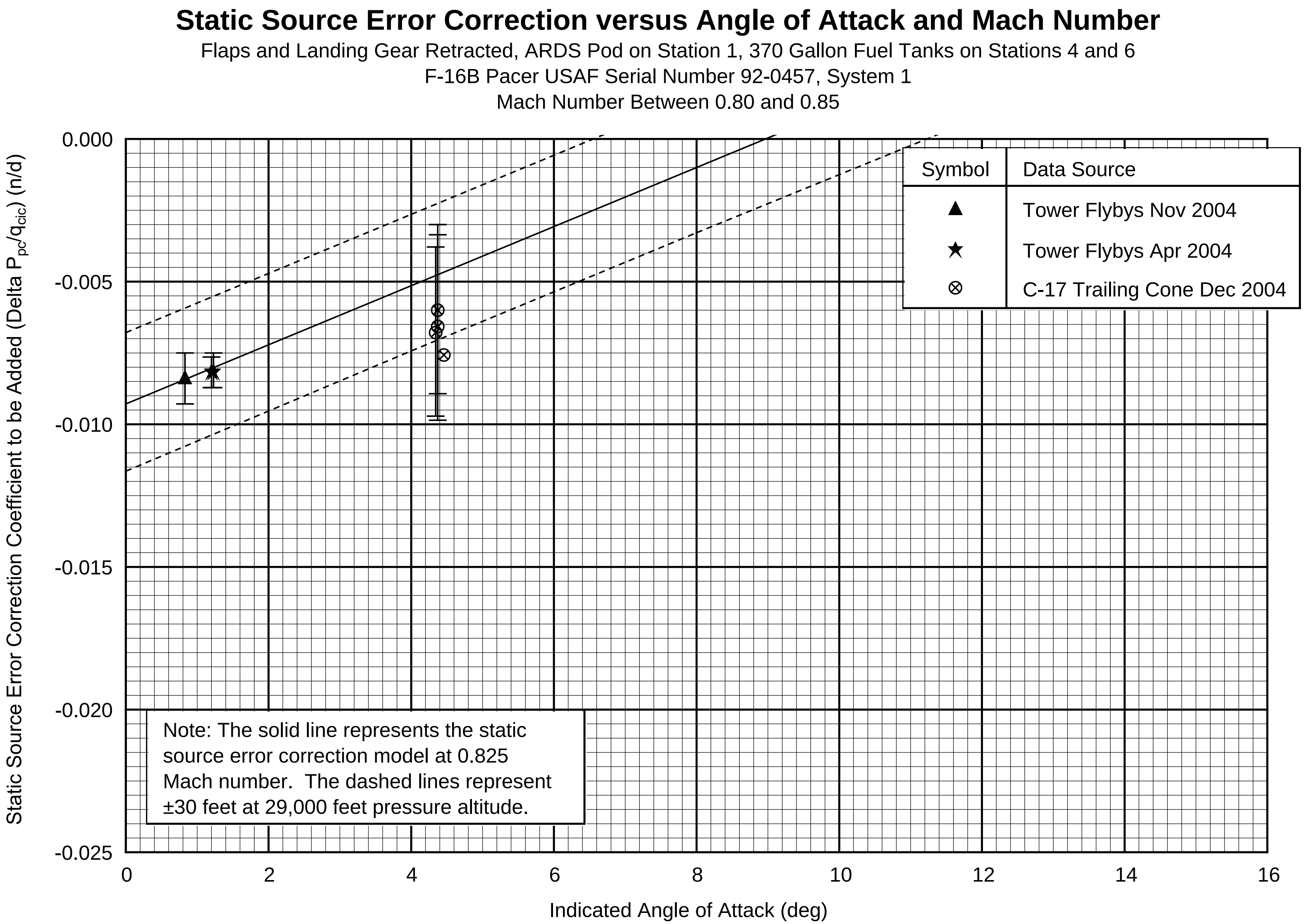

Figure D5 Static Source Error Corrections for Mach Numbers Between 0.80 and 0.85 - Uncertainty

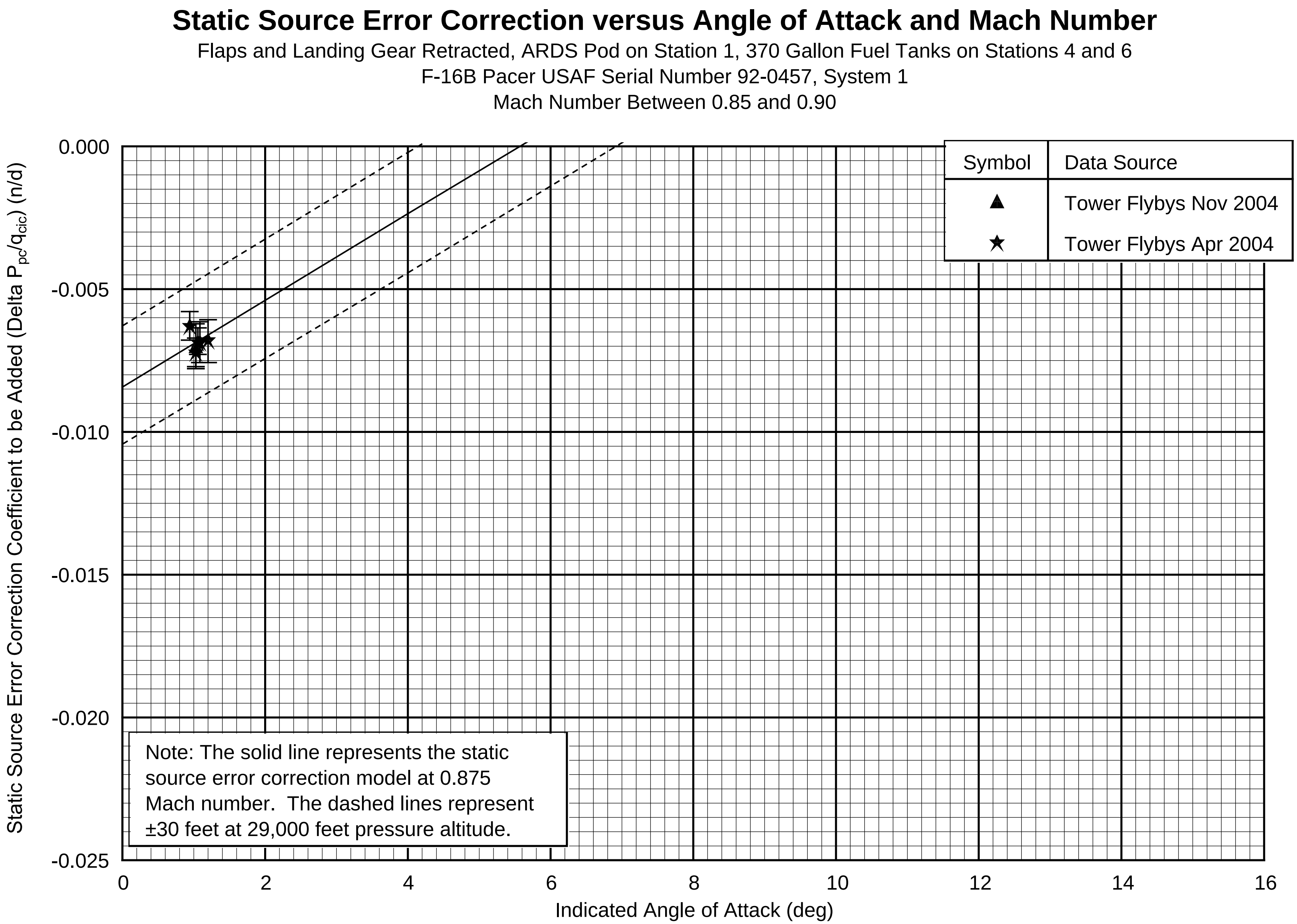

Figure D6 Static Source Error Corrections for Mach Numbers Between 0.85 and 0.90 - Uncertainty

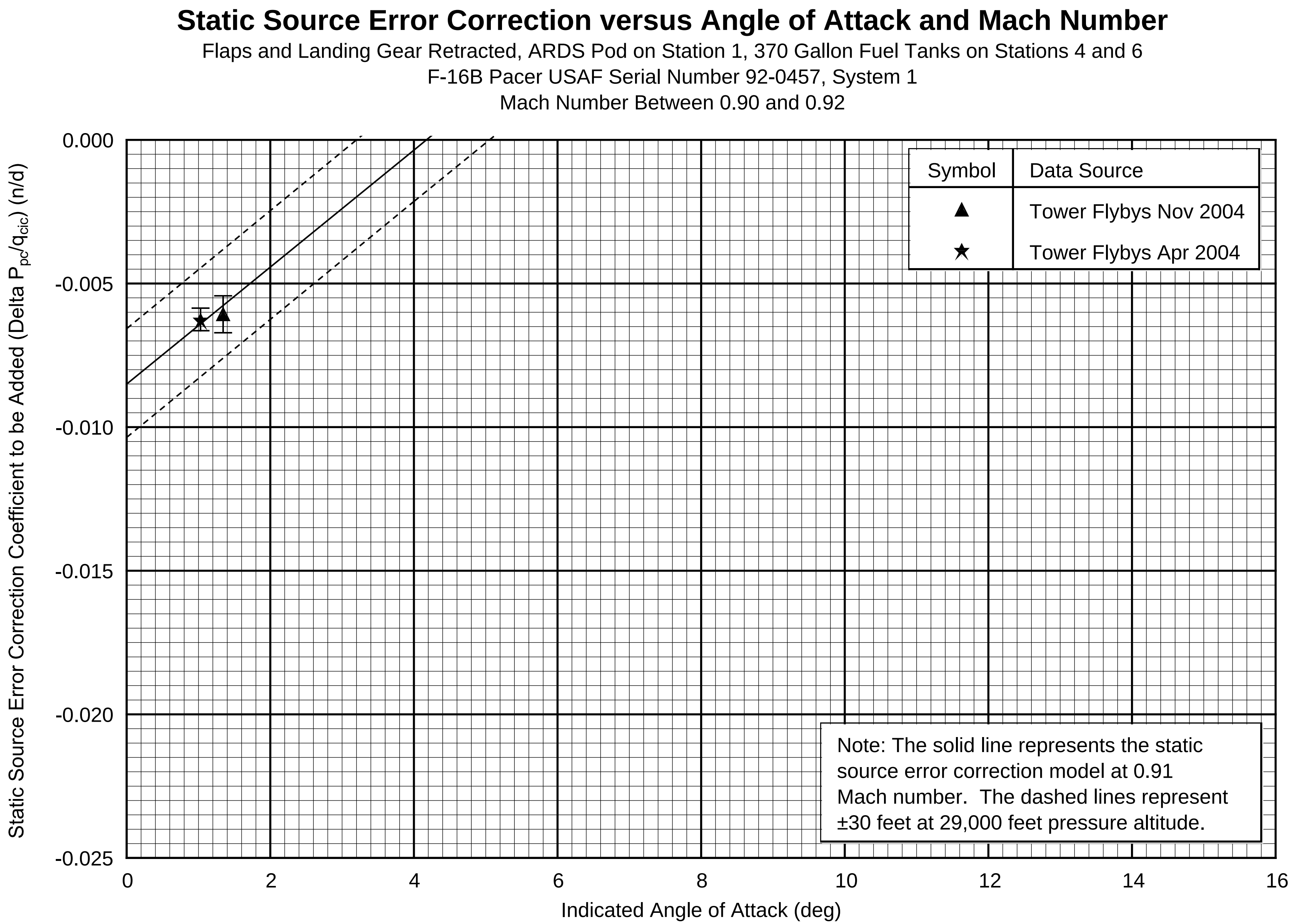

Figure D7 Static Source Error Corrections for Mach Numbers between 0.90 and 0.92 - Uncertainty

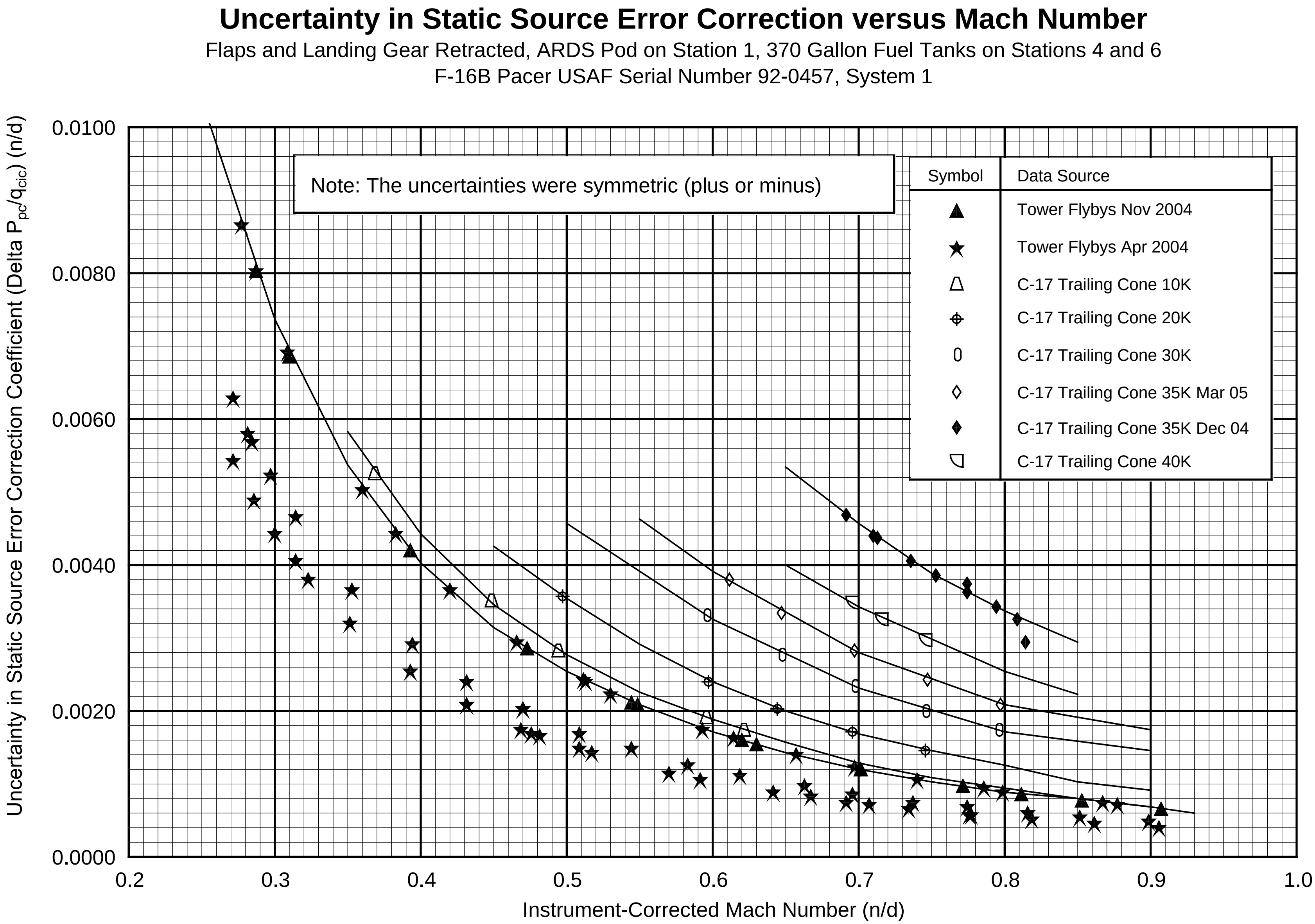

Figure D8 Uncertainty in Static Source Error Correction Coefficients

Uncertainty in Static Source Error Correction versus Mach Number

Flaps and Landing Gear Retracted, ARDS Pod on Station 1, 370 Gallon Fuel Tanks on Stations 4 and 6
F-16B Pacer USAF Serial Number 92-0457, System 1

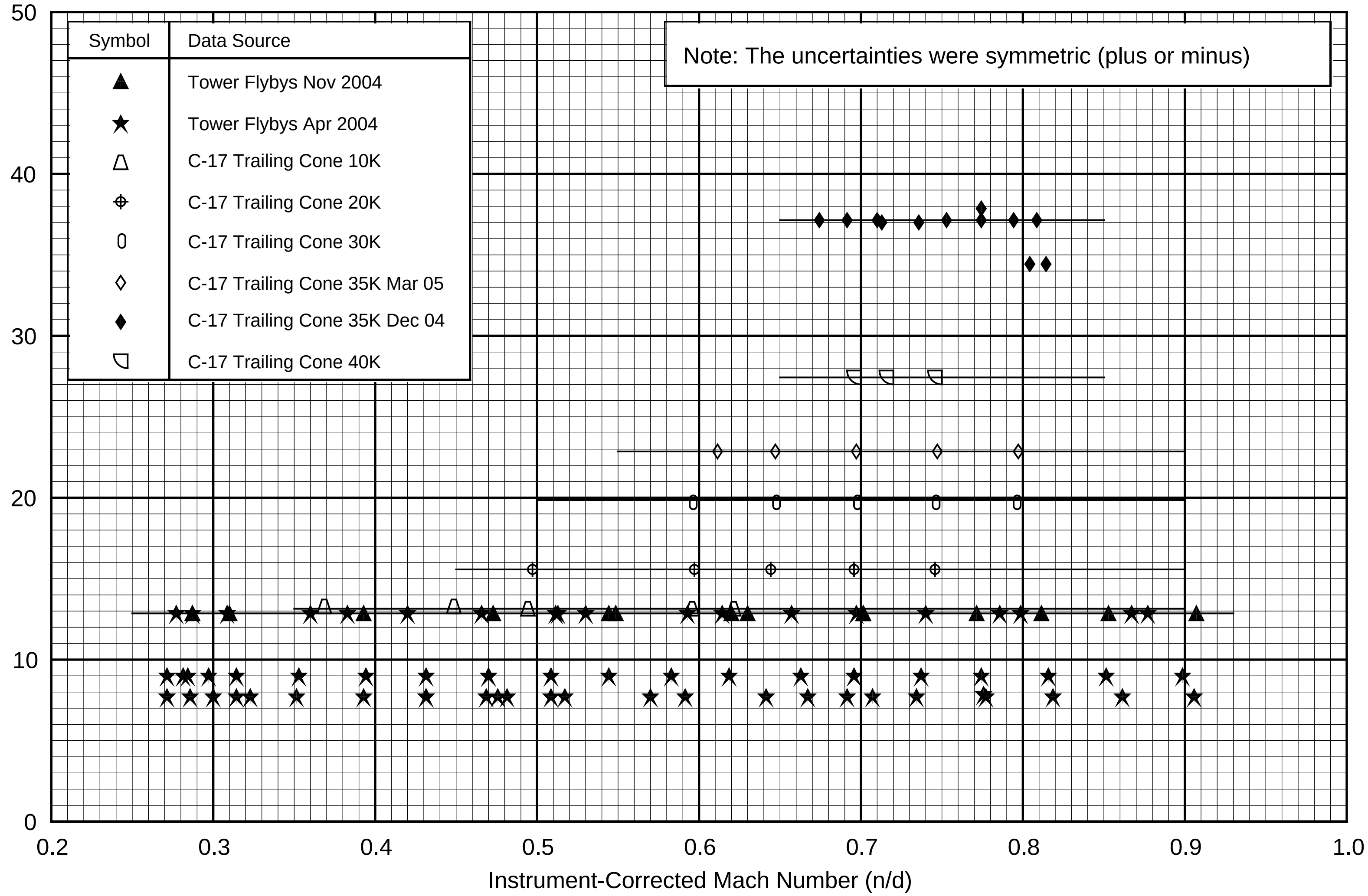

Figure D9 Uncertainty in Altitude Static Source Error Corrections

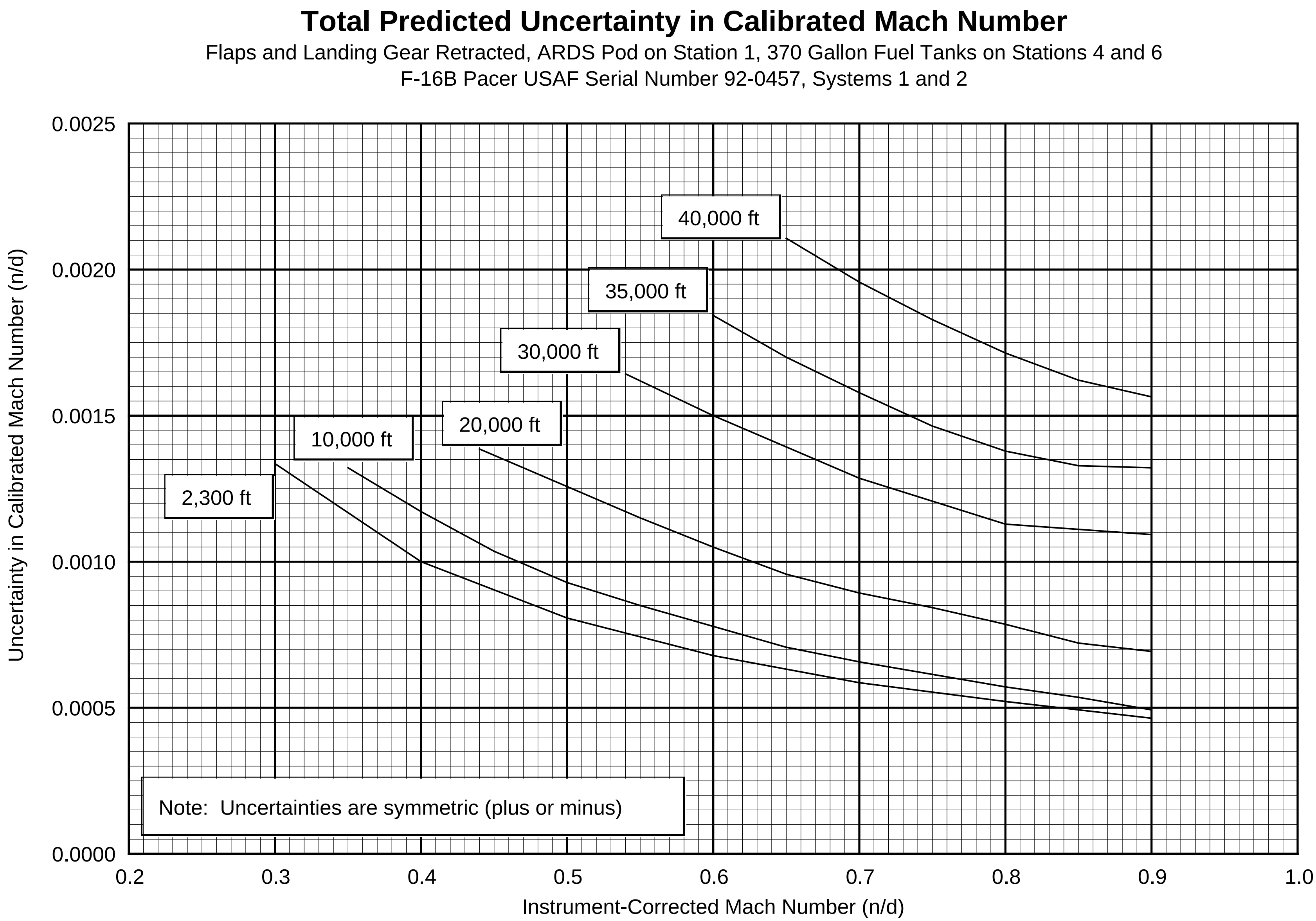

Figure D10 Total Predicted Uncertainty in Calibrated Mach Number

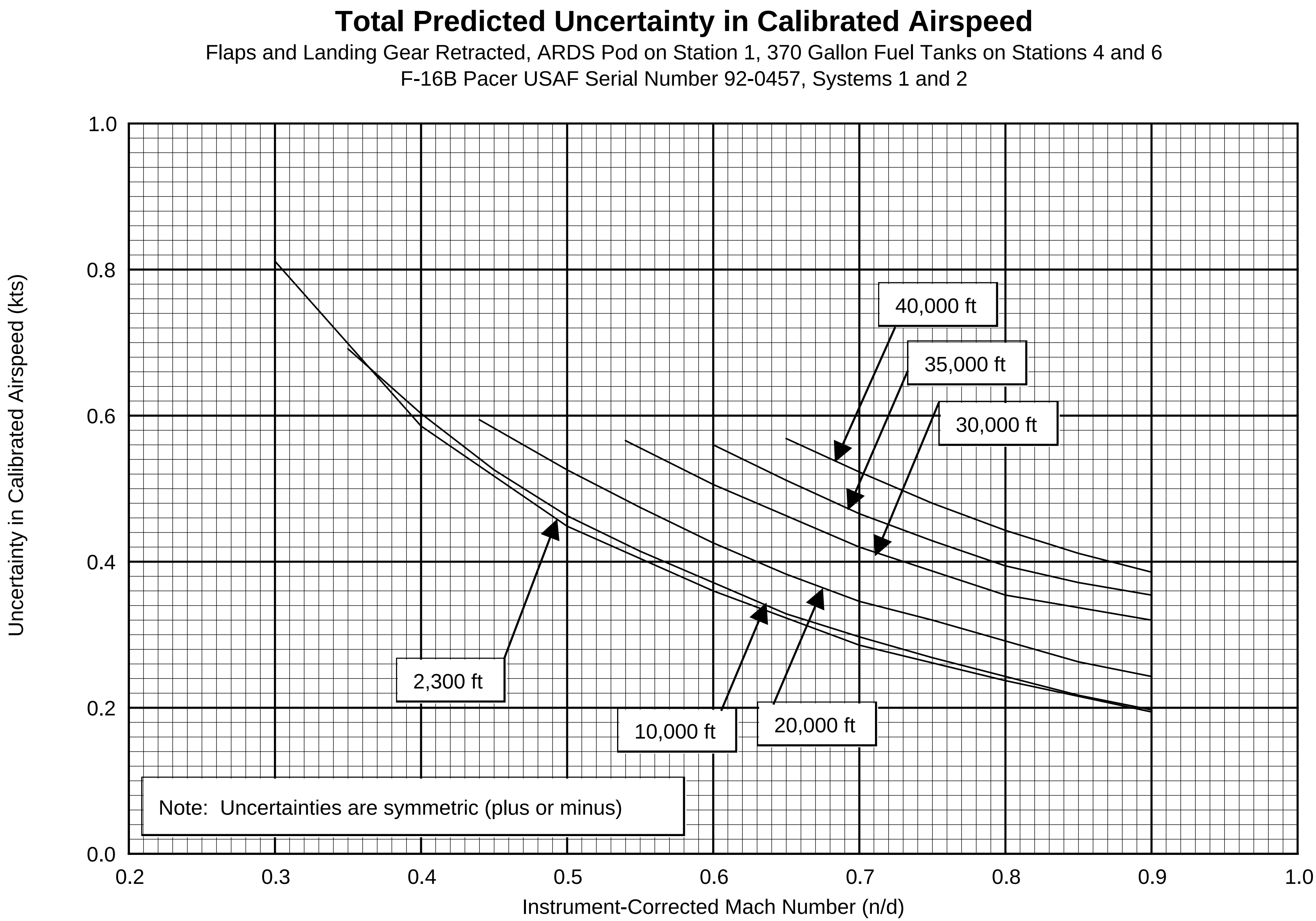

Figure D11 Total Predicted Uncertainty in Calibrated Airspeed

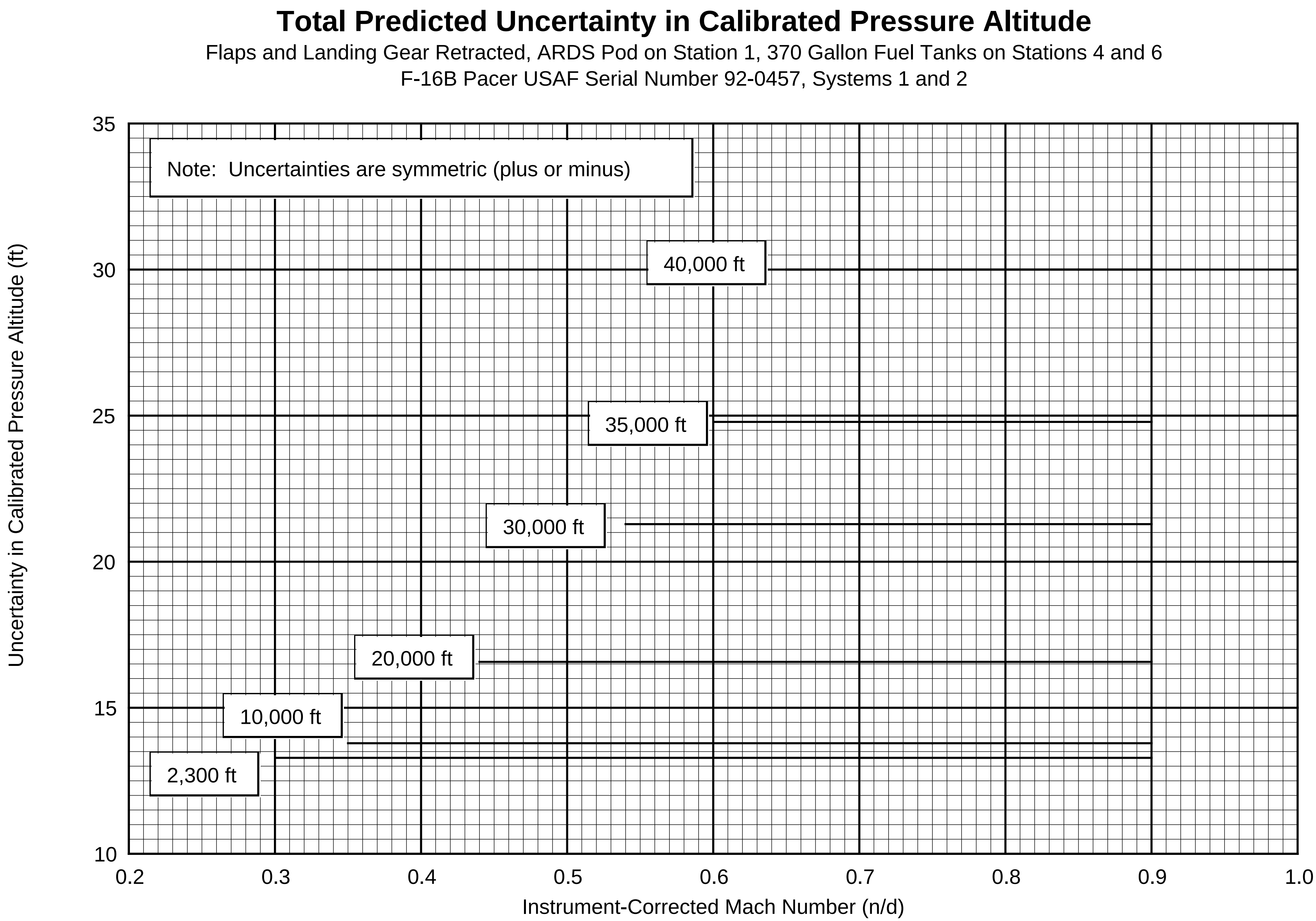

Figure D12 Total Predicted Uncertainty in Calibrated Pressure Altitude

APPENDIX E - LIST OF ABBREVIATIONS, ACRONYMS, AND SYMBOLS

Abbreviation	Definition	Units
a	local speed of sound	knots
AATIS	advanced Airborne Test Instrumentation System	---
ADS	air data system	---
AFB	Air Force base	---
AFFTC	Air Force Flight Test Center	---
AGL	above ground level	---
AMUX	avionics multiplex	---
ARDS	advanced range data system	---
ATIS	Airborne Test Instrumentation System	---
a_{SL}	speed of sound at sea level on a standard day, 661.48 knots	knots
B	bias limit	---
b	y-intercept of static source error correction model	n/d
$b(M_{ic})$	SSEC model intercept as a function of instrument-corrected Mach number	n/d
Bi	elemental bias uncertainty	---
C	Celsius	C
CADC	central air data computer	---
DGPS	differential global positioning system	---
DLT	Digital Linear Tape	---
EU	engineering unit	---
FCP	front cockpit	---
GMT	Greenwich Mean Time	---
GPS	global positioning system	---
GR	flyby tower grid reading	n/d
H_c	calibrated pressure altitude	feet

LIST OF ABBREVIATIONS, ACRONYMS, AND SYMBOLS (Continued)

Abbreviation	Definition	Units
$h_{GPS,ARDS}$	geometric altitude from the ARDS DGPS	feet
$h_{GPS,C\text{-}17}$	geometric altitude from the C-17 DGPS	feet
H_{ic}	instrument-corrected pressure altitude	feet
H_{pZGL}	pressure altitude measured at zero grid line of the flyby tower	feet
IRIG-B	Inter-Range Instrumentation Group – B timecode	---
KCAS	knots calibrated airspeed	---
KIAS	knots indicated airspeed	---
K_R	total temperature probe recovery factor	n/d
l_x	moment arm along x axis between center of gravity and inertial reference point	feet
l_y	moment arm along x axis between center of gravity and inertial reference point	feet
l_z	moment arm along x axis between center of gravity and inertial reference point	feet
m	slope of the equation for the static source error correction model	n/d
$m(M_{ic})$	SSEC model slope as a function of instrument-corrected Mach number	(1/degree)
MAC	mean aerodynamic chord	pct
MARS-II	Multi-Application Recorder/Reproducer System-II	---
M_c	calibrated Mach number	n/d
MDBM	multiple data bus monitor	---
M_{ic}	instrument-corrected Mach number	n/d
M_{ic},corr	instrument-corrected Mach number corrected for formation errors	n/d
$\mathbf{M}_{\phi}$	coordinate system transformation matrix	n/d
$\mathbf{M}_{\theta}$	coordinate system transformation matrix	n/d

LIST OF ABBREVIATIONS, ACRONYMS, AND SYMBOLS (Continued)

Abbreviation	Definition	Units
$\mathbf{M}_{\psi}$	coordinate system transformation matrix	n/d
n	number of samples	---
N/A	not available	---
n/d	nondimensional	---
NIST	National Institute of Standards and Technology	---
p	angular rate about the roll axis	deg/sec
P	precision limit	---
P_a	ambient air pressure	in Hg
P_{aSL}	ambient air pressure at sea level on a standard day, 29.92126 in Hg	in Hg
PC	personal computer	---
PCM	pulse code modulation	---
PJB	power junction box	---
P_s, cone	static pressure measured by the C-17 trailing cone	in Hg
P_{si}, Psi	indicated static pressure	in Hg
P_{sic}	instrument-corrected static pressure	in Hg
P_{sic}, corr	instrument-corrected static pressure corrected for formation errors	in Hg
P_t	total air pressure	in Hg
P_{ti}	indicated total pressure	in Hg
P_{tic}	instrument-corrected total pressure	in Hg
q	angular rate about the pitch axis	deg/sec
q_c	compressible dynamic pressure	in Hg
q_{cic}	instrument-corrected compressible dynamic pressure	in Hg
r	angular rate about the yaw axis	deg/sec

LIST OF ABBREVIATIONS, ACRONYMS, AND SYMBOLS (Continued)

Abbreviation	Definition	Units
RCP	rear cockpit	---
RVSM	Reduced Vertical Separation Minimal	---
S	standard deviation	---
S/N	serial number	---
SCU	system control unit	---
SPCM	small pulse code modulation	---
SSEC	static source error correction	---
t	student's t statistic	n/d
T_a	test-day ambient air temperature	---
Ta_{SD}	standard day temperature at a given pressure altitude	K
T_{aSL}	ambient air temperature at sea level on a standard day	---
TaSL	ambient air temperature at sea level on a standard day, 288.15 K	K
T_{aZGL}	ambient air temperature measured at the zero grid line of the flyby tower	deg F
T_{aZGL}	temperature at zero grid line	---
TCD	time code display	---
TPS	test pilot school	---
TPS	Test Pilot School	---
TR	technical report	---
T_{ti}	indicated total air temperature	---
T_{ti}	indicated total air temperature	K
T_{tic}	indicated total air temperature measured by the probe corrected for instrument errors	K

LIST OF ABBREVIATIONS, ACRONYMS, AND SYMBOLS (Continued)

Abbreviation	Definition	Units
USAF	United States Air Force	---
Uy	uncertainty in the result	---
V_c	calibrated airspeed	knots
V_D	inertial velocity in the down direction	ft/sec
V_E	inertial velocity in the East direction	ft/sec
V_{ic}	instrument-corrected airspeed	knots
V_N	inertial velocity in the North direction	ft/sec
VP	virtual processor	---
V_t	true airspeed	knots
V_w	wind velocity	knots
V_{wD}	downward component of wind velocity	knots
V_{wE}	East component of wind velocity	knots
V_{wN}	North component of wind velocity	knots
V_x	inertial velocity along the body x axis	ft/sec
V_y	inertial velocity along the body y axis	ft/sec
V_z	inertial velocity along the body z axis	ft/sec
wy	propagated uncertainty in the result	---
wy	uncertainty in the independent variable	---
ZGL	zero grid line of flyby tower	---
Δh	difference in geometric altitude between the zero grid line of the flyby tower and the aircraft	feet
ΔH_{GPS}	formation error correction based on DGPS	feet
ΔH_p	difference in pressure altitude between the zero grid line of the flyby tower and the aircraft	feet
$\Delta h_{\theta,C\text{-}17}$	C-17 pitch angle correction	feet

LIST OF ABBREVIATIONS, ACRONYMS, AND SYMBOLS (Concluded)

Abbreviation	Definition	Units
$\Delta H_{\theta,\mathrm{kiel}}$	Difference in pressure altitude between the trailing cone pressure transducer and the kiel probe pressure transducer	---
ΔM_{pc}	Mach number position error correction to be added	n/d
$\Delta P_{\mathrm{pc}}/q_{\mathrm{cic}}$	static source error correction coefficient to be added to instrument-corrected static pressure	n/d
ΔP_{sic}	instrument error correction to be added to static pressure	in Hg
$\Delta P_{\mathrm{t}}/q_{\mathrm{cic}}$	total pressure error correction	n/d
ΔP_{tic}	instrument error correction to be added to total pressure	in Hg
ΔV_{pc}	airspeed position error correction to be added	knots
ΔV_{tc}	airspeed total pressure error correction to be added	knots
α	true angle of attack	degrees
α_{i}	indicated angle of attack	degrees
β	true angle of sideslip	degrees
δ	ambient air pressure ratio	n/d
ϕ	roll angle	degrees
θ	pitch angle	degrees
$\theta_{\mathrm{C\text{-}17}}$	pitch angle of C-17 as measured by its production inertial reference unit	degrees
ψ	heading angle	degrees
ψ_{w}	wind direction from true North	degrees

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